Rhode Island Department of Environmental Management
Class IV Soil Evaluator Examination
Study Guide

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Purpose

The purpose of this study guide is to provide information to exam applicants concerning exam format, general content of the exam and equipment required for the field component; it is not intended to provide the technical foundation necessary to pass the exam.

You are expected to have an understanding of the general configuration and function of septic systems. This guide includes some fundamental information relating to these topics. If these topics are new to you or are unclear, you should refer to the reference list provided at the end of this compilation for sources of information you could consult to improve your understanding of topics of which your understanding is weak.

Additionally, you must have an understanding of the ISDS regulations. The ISDS regulations are available on the DEM website. To navigate to this document from DEM home at: http://www.state.ri.us/dem, select "Programs", then "ISDS", and then from the panel on the right side of the screen the link "Listing of ISDS Regulations"

When you study the regulations, do not neglect to review Appendix 1 and 2. Appendix 1 discusses soil morphology, soil description; Appendix 2 discusses soil characteristics, associated landforms and on-site considerations.

Responsibilities of a Licensed Soil Evaluator

Once the exam is passed, be aware that a licensed soil evaluator has responsibilities beyond conducting the soil evaluation service for clientele.

Regulatory Permitting Requirements
It is the responsibility of the licensee to follow the regulations concerning submission of applications for permitting-related activity and data to the Department.

Renewal of License
Soil evaluator licenses are renewable in December of odd-numbered years, a two-year renewal cycle. The soil evaluator license is a separate license under the DEM ISDS designer licensing program and renewal must be requested independent of other licenses you may possess. Renewal requires submission to the Department of a renewal application form, with a renewal fee of $100 and documentation of required continuing education.

Continuing Education
Required continuing education is 8 "classroom hours" every two-years; note that "classroom hours" is a description of credit value and not a measure of contact time. Continuing education must be obtained after the license is issued and during the two-year license cycle (there is no provision for banking credit overages for the next renewal). The URI Onsite Wastewater Training Center releases a schedule of events in the spring; the ISDS licensing section of the DEM website provides a link to the Training Center. The ISDS Licensing section of the DEM website also provides information concerning continuing education events available. The ISDS licensing section of the website may be located from DEM home at: http://www.state.ri.us/dem by selecting "Programs", then "ISDS", then from the left side of the screen, the link to the "Installers and Designers Licensing Program". Licensees are encouraged to seek additional opportunities, in the form of courses, seminars or workshops. If a licensee identifies an event which might be suitable for continuing education credit, as much specific information about the content of the event as possible, should be provided to the ISDS program for evaluation. The more lead-time provided for this review, the greater the likelihood of obtaining a determination in time to register for the event.

<u>Examination logistics</u>

Location and Time
Specific instructions concerning location of the exam and the time by which you must arrive will be provided to applicants after the exam application deadline. These specific instructions will include a map and driving directions to the exam location and the time by which you must arrive at the location of the exam.

Weather
Arrive on time even if it rains. Weather conditions will be evaluated in the field the morning of the exam. The rain date for the field exam will be scheduled based on the weather forecast the day of the exam and for the day following the exam. The rain date decision will be made the day of the exam, so you must arrive at the location specified in the exam-specific instructions as scheduled.

Lunch
If you are taking both components of the exam, bring your lunch. The exam-day schedule is highly structured and is not flexible. <u>*If you leave for lunch and are late returning, there will be no special accommodation made to provide you with extra time to complete your afternoon component.*</u>

An example exam day schedule is included in this guide so you will know what to expect the day of the exam.

Examination Specifics

Two Components: Written Examination and Field Examination

Each section will be graded separately. Both must be passed. They do not have to be passed concurrently. If more than 2 years elapse between passing both components, the component originally passed must be retaken. Examinees will be notified of results in writing within 60 days after the examination date. *

Examination Content *

- Principles of on-site sewage treatment and disposal;
- Understanding of the applicable state regulations;
- Geology and soils of Rhode Island;
- Soil textural analysis and profile descriptions;
- Estimating mean seasonal high groundwater elevations using soil morphology; and
- Soil moisture and drainage characteristics of soils.

*Information from ISDS Regulations, Section 25.03

Written Examination Format

- Closed-book
- Multiple choice
- Fill-in the blank
- True/false
- 2 hours to complete (No talking will be allowed. When finished and your exam is turned in, you may leave the room.)

Field Examination Format

- Three soil pits will be evaluated
- Complete a Field Card (provided by DEM the day of the exam) for each of the three pits
- Guidance materials are permitted for the field examination

At the pits (50 minutes per pit, 10 minutes transit to the next pit)

- 6 examinees (maximum), each group's DEM guide and pit monitor will be present at each pit

Sequence:

Group A (3 examinees)	Group B (3 examinees)
10 minutes in	10 minutes out
20 minutes out	20 minutes in
15 minutes in	15 minutes out
5 minutes out (cards collected at end of 5 minute interval)	5 minutes in (cards collected on way out of pit)
Depart for the next pit.	**Depart for the next pit.**

Example Exam Day Schedule

Rhode Island Department of Environmental Management
Class IV Soil Evaluator Examination

SCHEDULE

Groups 1, 2, 3		Groups 4, 5, 6	
8:30 – 8:45	Registration	8:30 – 8:45	Registration
8:45 – 9:00	Distribution of exams/instructions	8:45	Depart Parking Area for assigned soil pits
9:00 – 11:00	Written exam	8:50 – 9:40	Each group's first pit
11:00 – 12:00	Lunch		Group 4 – Pit 1
12:30	Depart Parking Area for assigned soil pits		Group 5 – Pit 2
12:40 – 1:30	Each group's first pit		Group 6 – Pit 3
	Group 1 – Pit 1	9:40 - 9:50	Transit to next pit
	Group 2 – Pit 2	9:50 – 10:40	Each group's second pit
	Group 3 – Pit 3		Group 4 – Pit 2
1:30 - 1:40	transit to next pit		Group 5 – Pit 3
1:40 – 2:30	Each group's second pit		Group 6 – Pit 1
	Group 1 – Pit 2	10:40 -10:50	Transit to next pit
	Group 2 – Pit 3	10:50 – 11:40	Each group's third pit
	Group 3 – Pit 1		Group 4 – Pit 3
2:30 - 2:40	transit to next pit		Group 5 – Pit 1
2:40 – 3:30	Each group's third pit		Group 6 – Pit 2
	Group 1 – Pit 3	11:40 - 11:50	Transit to Parking Area
	Group 2 – Pit 1	11:50 – 12:50	Lunch
	Group 3 – Pit 2	1:05 – 1:15	Distribution of exams/instructions
3:30 - 3:40	Transit to Parking Area	1:20 – 3:40	Written Exam

Field Examination

Required equipment for the field component

- **Soil Color Book**

  Munsell Soil Color Books are available from:

  Forestry Suppliers Inc.
  P.O. Box 8397
  Jackson, MS 39284-8397
  Tel: (800) 647-5368, Fax: (800) 543-4203
  http://www.forestry-suppliers.com

  Ben Meadows: http://www.benmeadows.com
  Phone 1-800-241-6401
  Fax 1-800-628-2068

- **Clip board**
- **Pencils & Erasers**
- **Water bottle**
- **Towel**
- **Soil knife**
- **Any guide materials you would use in the field for soil evaluation**
- **Plastic bag or other method to shield your recording sheet from inclement weather**
- **Back pack, bucket or a bag for toting clothing and equipment**
- **Specimen tin to hold soil samples (disposable muffin pans work well)**
- **"Sharpie" marker for labeling tin**
- **Masking tape on which to label specimen tin**

You will be in the field for 3 hours, the following are suggested:

- **Wear appropriate field attire (boots and jeans)**
- **Bring "layers" of clothing, consider a hat**
- **Be prepared for light rain**
- **Consider an extra pair of shoes**
- **Insect repellant is recommended**
- **Sun screen may be desired**

DEM will supply for use at the examination:

- **Spades**
- **Clinometers**
- **USGS map of the area**
- **Cards on which to record field exam information**

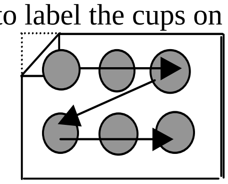
Recording Information at the Soil Pits

Control Section

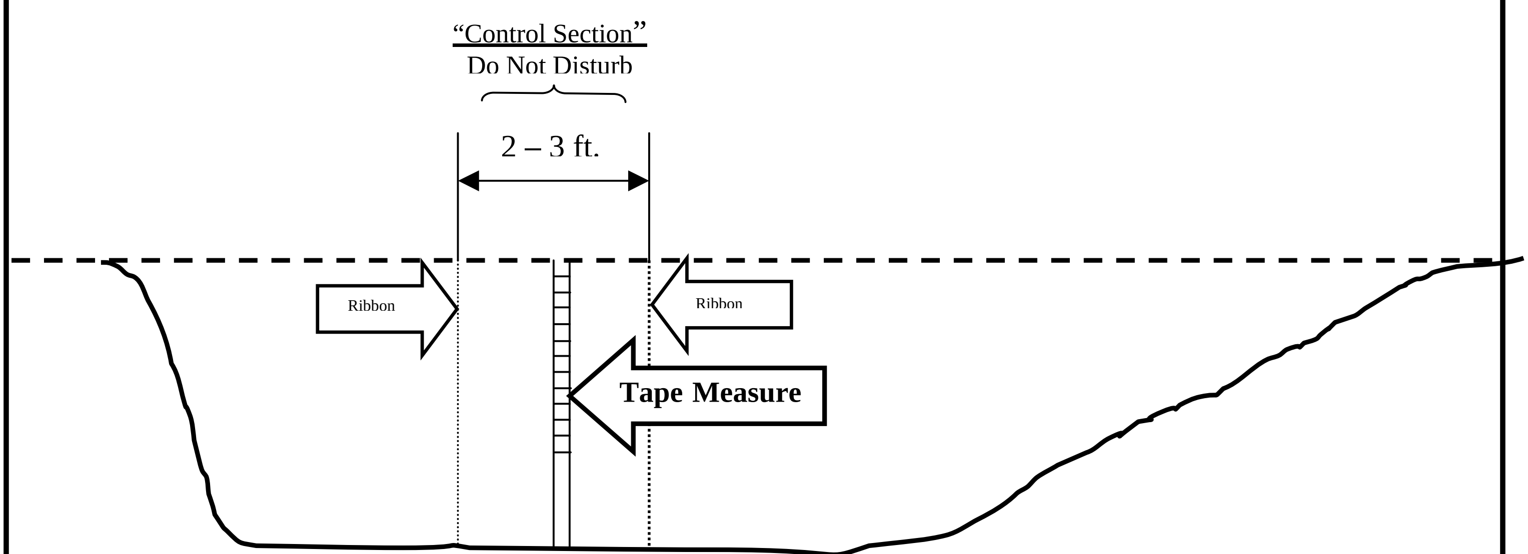
- The control section is a section of the pit wall of approximately two to three feet in width. The boundaries of the control section will be marked with ribbon.

- **The control section is the part of the soil profile you must describe.**

- **You will <u>collect soil samples from outside the boundaries of the control section</u> for evaluation of required properties**.
- At the pit, time is scheduled in and out of the pit. It is recommended that you use muffin pans (or any other method you may devise) to collect your soil samples in the pit for texturing and coloring during your rotation out of the pit.
  A disposable aluminum muffin pan with one corner folded in can be keyed to a sketch you draw on your filed card, so that you do not have to label the cups on the pan. **Example:**



Cross Section of Pit Showing Control Section



Recording Information at the Soil Pits

An example of the card on which you will record your observations is depicted on the next page. You will note that the card used for the field component of the Soil Evaluator Exam is different from the DEM Site Evaluation Report Form on which the soil evaluation is recorded.

Field Exam Reporting Card - Side 1

On side 1 of the field exam reporting form, each element of soil description is presented in a distinct column; this requires that each element of the description be considered individually during the exam, as one is describing each element of a soil horizon.

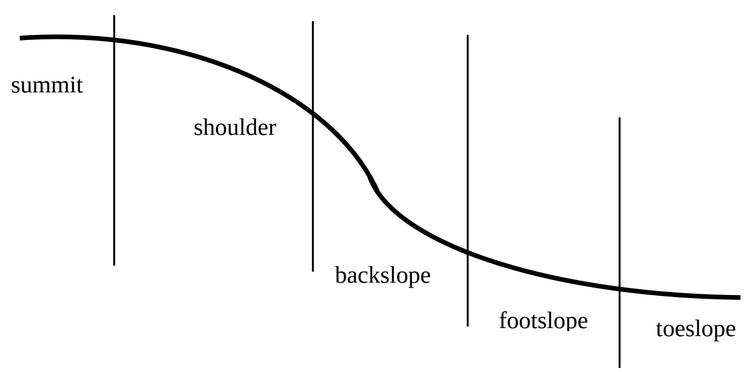
If you do not observe a characteristic, draw a line through the box indicating that you have considered that element, but that it was not observed. If a box is left blank, without such a mark, it will be assumed that you were not able to make a determination, which will negatively influence your score.

Depth must be recorded in inches.

Nomenclature which must be used is keyed by each section of the field exam reporting card to the pages in Appendix 1 of the ISDS regulations on which each is described, on the page following side 2 of the example card which follows.

Field Exam Reporting Card - Side 2

Landform and Landscape position - On side 2 of the field exam reporting form, you are required to identify the type of landform in which the test pit is located as well as the landscape position (hillslope profile position) of the pit. Landforms are discussed later in this study guide. Below is a simple diagram of landscape position.



Slope - You will be required to record the slope of the land within which the pit has been excavated. A clinometer will be available at each pit for determination of slope. There will be time before the exam begins to practice using the clinometer to determine slope.

Parent Material(s) - Note that if 2 parent materials are observed both must be recorded.

RHODE ISLAND DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
CLASS IV SOIL EVALUATION EXAMINATION

NAME: ____ **PIT #:** ____________________

HORIZONATION					BOUNDARY		TEXTURE		COLOR			STRUCTURE			MOIST CONSIST.	REDOX FEATURES			
Prefix	Master	Sub.	No.	Depth (in)	Distinct.	Topo	Coarse Fragment Modifier	Class	Hue	Value	Chroma	Grade	Shape	Size		Depletions		Concentrations	
																Abundance	Contrast	Abundance	Contrast

Format of card used for the field component of the Class IV Exam.

Side 1

Nomenclature is described and keyed to pages in Appendix 1of the ISDS regulations on the page following Side 2 of this data card

- Record depth in inches
- If you do not observe a characteristic, draw a line through the box indicating that you have considered that element, but that it was not observed. Boxes which are left blank without such a mark, will be assumed to indicate that you were not able to make a determination, which will negatively influence your score.

Depth to limiting layer (inches): ______________

Depth to groundwater or seepage (inches): ______________

Depth to seasonal high watertable (inches): ______________
(if below soil profile, so indicate)

NOTE:
If two parent materials are present, record both of them

SITE INTERPRETATION

Landform	Landscape Position	Slope	Parent Material (s)
______ Floodplain	______ Summit	______ 1 – 3%	______ Eolian Deposits
______ Stream Terrace	______ Shoulder	______ 3 – 8%	______ Glacial Ice Contact
______ Coastal Dune	______ Backslope	______ 8 – 15%	______ Proglacial Outwash
______ Depression	______ Foot slope	______ 15 – 25%	______ Dense Glacial Till
______ Moraine (Recessional/Terminal)	______ Toe slope	______ 25 – 35%	______ Loose Glacial Till
______ Drumlin	______ None	______ > 35%	______ Dune
______ Till Ridge			______ Alluvial
______ Outwash Plain			______ Other (organic soils)
______ Esker, Kame or Kettle			
______ Other Upland Area			

Format of card used for the field component of the Class IV Exam.

Side 2

Landforms, soil characteristics and parent material are discussed in Appendix 2 of the ISDS Regulations

Nomenclature to be used on Soil Pit Reporting Cards

*******NOTE: Page numbers indicate the page in Appendix 1 in the January 2002 ISDS Regulations *******

Horizonation:

- **"Prefix"** – Indicates a lithologic discontinuity; see page 89-90 "Discontinuities".
- **"Master"** (Master Horizon, abbreviated O, A, E, B, C, R)– See page 86 "Master Horizons" and page 87 Transitional Horizons. Record the top of the 1st mineral horizon.
- **"Sub."** (Subordinate distinction) – See page 88 "Subordinate Distinctions within Master Horizons".
- **"No."** (Number) – See page 89 "Vertical Subdivisions".

Boundary:

- **"Distinct."** (Distinctness, abbreviated a, c, g, d) – See page 100 "Horizon Boundaries".
- **"Topo"** (Topography, abbreviated s, w, i, b) – See page 100 "Horizon Boundaries".

Texture: – Discussion of elements of texture begins on page 94

- **"Coarse Fragment Modifier"** – See page 97 "Coarse Fragment Modifiers"
- **"Class" –** See pages 96 and 97 "Sand Size Modifiers" and "Textural Classes"

Color: - See page 90 "Color"

- **"Hue"** – (A component used to describe color in Munsell color notation)– See page 91.
- **"Value"** – (A component used to describe color in Munsell color notation)– See page 91.
- **"Chroma"** – (A component used to describe color in Munsell color notation)– See page 91.

Structure: – See pages 98 – 99 "Structure", "Type", "Size", "Grade"

- **"Grade"** – See page 98 – 99 "Grade"
- **"Shape"** – Abbreviated gr, pl, abk, sbk, pr, sg, m. See page 99 "**Type**"
- **"Size"** – See Page A1 – 13 – 14 "Size", also refer to Figures 6 and 7

Moist Consist (Moist Consistence, abbreviated l, vfr, fr, fi, vfi, efi) – See page 99-100 "Consistence".

Redox Features

Depletions: See page 91 "Redoximorphic Features" and Page 93 "Redox Depletions"

- **Abundance** – See page 92 "Abundance of Redoximorphic Features"
- **Contrast -** See page 92 "Contrast of Redoximorphic Features"

Concentrations: See page 91 "Redoximorphic Features" and Page 93 "Redox Concentrations"

- **Abundance** – See page 92 "Abundance of Redoximorphic Features"
- **Contrast -** See page 92 "Contrast of Redoximorphic Features"

Depth to limiting layer (inches): If observed, record the depth to horizon which is limiting to water movement. This may be evidenced by but not limited to a Cd horizon (densipan) or conditions which result in a perched watertable. "Impervious" for purposes of determining ISDS suitability is defined in the ISDS regulations.

Depth to groundwater or seepage (inches): If observed, record the depth to water or water seeping in on the pit wall.

Depth to seasonal high watertable (inches): If observed, record depth to seasonal high watertable (Clue – think about redox features!), if below the observed soil profile, so indicate.

On the back side of the card: Be aware that if two **Parent Materials** are observed, record both of them

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
Department of Environmental Management
Office of Water Resources

Site Evaluation Form
Part A - Soil Profile Description

Application Number ____________

Property Owner: ______________________________

Property Location: ______________________________

Date of Test Hole: ______________________________

Soil Evaluator: ______________________ License Number: ______________

Weather: ______________________ Shaded: Yes☐ No☐ Time: ____________

TH______ Horizon	Depth	Horizon Boundaries		Soil Colors		Re-Dox Description			Texture	Structure	Consistence	Soil Category
		Dist	Topo	Matrix	Re-Dox Features	Ab.	S.	Con.				

Sample form used for DEM ISDS Site Evaluation Report

Part A (Side 1) Soil Evaluation

To be completed by a Class IV Soil Evaluator

TH______ Horizon	Depth	Horizon Boundaries		Soil Colors		Re-Dox Description			Texture	Structure	Consistence	Soil Category
		Dist	Topo	Matrix	Re-Dox Features	Ab.	S.	Con.				

Soil Class: ______________________ Total Depth of each Test Hole: ______________________

Depth to Groundwater Seepage: ______________________ Depth to Impervious or Limiting Layer: ______________________

Estimated Seasonal High Water Table: ______________________ Comments: ______________________

revised 5/8/01

Part B

Key:
- ■ Approximate location of test holes
- x% → Estimated gradient and direction of slope
- Approximate direction of due north

Site Evaluation – to be completed by Class II or III Designer or Soil Evaluator

Please use the area below to locate:

1. Test holes
2. Approximate direction of due north
3. Offsets from test holes to fixed points such as street, utility pole, or other permanent, marked object

Sample form used for DEM ISDS Site Evaluation

Part B (Side 2) Site Evaluation

To be completed by a Class IV Soil Evaluator,
or a Class II or III ISDS Designer

1. Relief and Slope:
2. Presence of any watercourse, wetlands or surface water bodies, within 200 feet of test holes: YES☐ NO☐ If yes, locate on above sketch.
3. Presence of existing or proposed private drinking water wells within 200 feet of test holes: YES☐ NO☐ If yes, locate on above sketch.
4. Public drinking water wells within 500 feet of test holes: YES☐ NO☐ If yes, locate on above sketch.
5. Is site within the watershed of a public drinking water reservoir or other critical area defined in SD 19.00? YES☐ NO☐
6. Has soil been excavated from or fill deposited on site? YES☐ NO☐ If yes, locate on above sketch.
7. Site's potential for flooding or ponding: NONE☐ SLIGHT☐ MODERATE☐ SEVERE☐
8. Landscape position:
9. Vegetation:
10. Indicate approximate location of property lines and roadways.
11. Additional comments, site constraints or additional information regarding site:____________________

Certification

The undersigned hereby certifies that all information on this application and accompanying forms, submittals and sketches are true and accurate and that I have been authorized by the owner(s) to conduct these necessary field investigations and submit this request.

Part A prepared by: Part B prepared by:

Signature License # Signature License #

FOR OFFICE USE ONLY

Decision: Approved ☐ Disclaimed ☐

Comments:____________________

Signature Authorized Agent Date

revised 5/8/01

Principles of on-site sewage treatment and disposal

Wastewater Characteristics

- Microorganisms
- Fecal Coliform
- Pathogens
- Nutrients
- Organic Chemicals
- Toxic Chemicals

Septic System Treatment

- Collect and separate solids and grease from wastewater
- Waste decomposition by physical, biological and chemical processes in the system and in the soil
- Disposal of the treated water

Principles of On-Site Sewage Treatment and Disposal

Function of a septic tank, d-box, drainfield

Biomat – What is it? How is it formed? Where is it formed? What does it do?

Long-term acceptance rate (LTAR)

Soil Physical Properties

Adsorption versus absorption

Denitrification

Nitrification

Aerobic versus anaerobic

Nutrients found in septic system effluent (nitrogen, phosphorous)

Nitrate

Regulatory

Percolation test

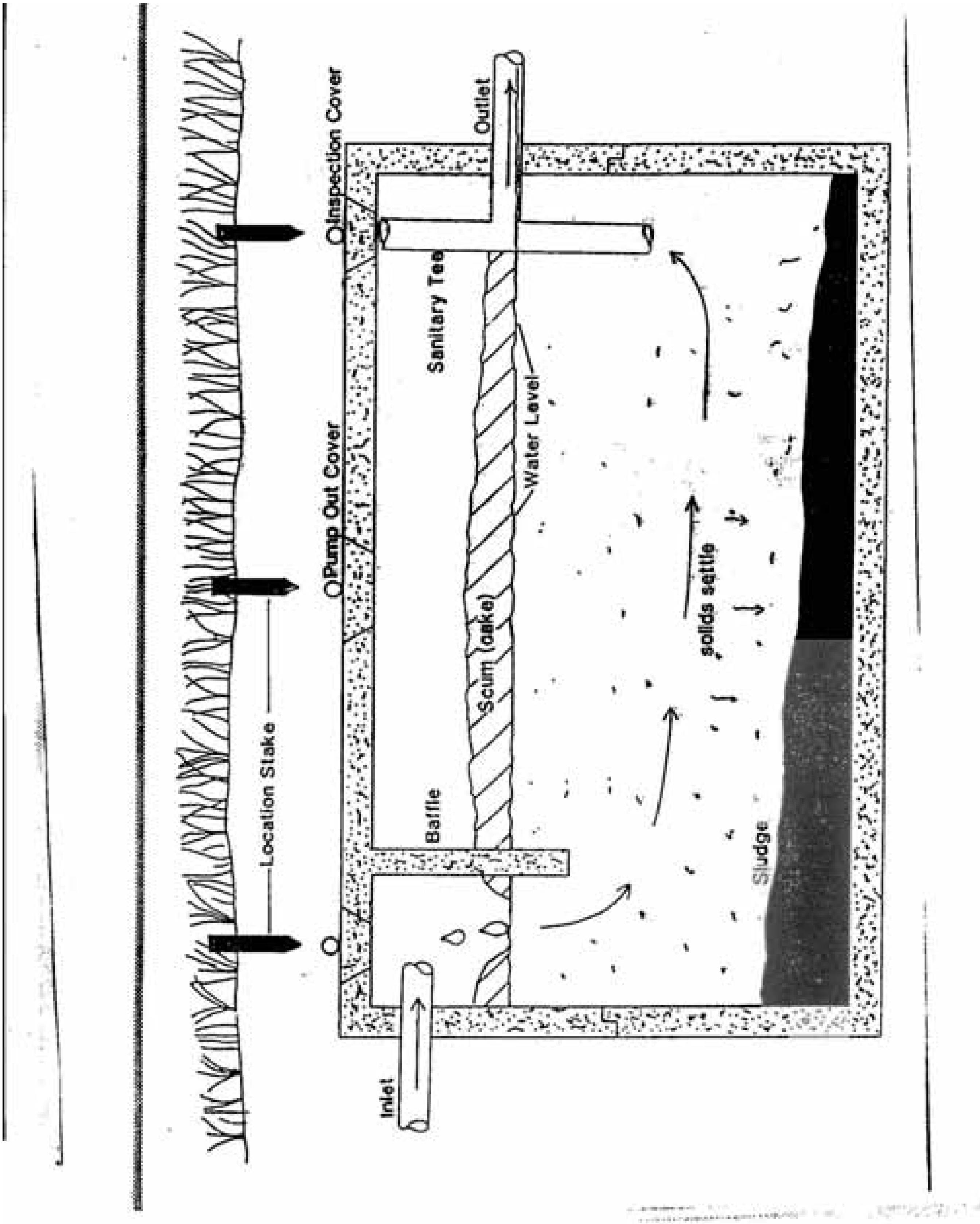
Site evaluation

Soil evaluation

Impervious in “ISDS Terms”

Proprietary treatment systems versus sand filters

Cross section of a single compartment septic tank



<u>Configuration of a conventional septic system</u>

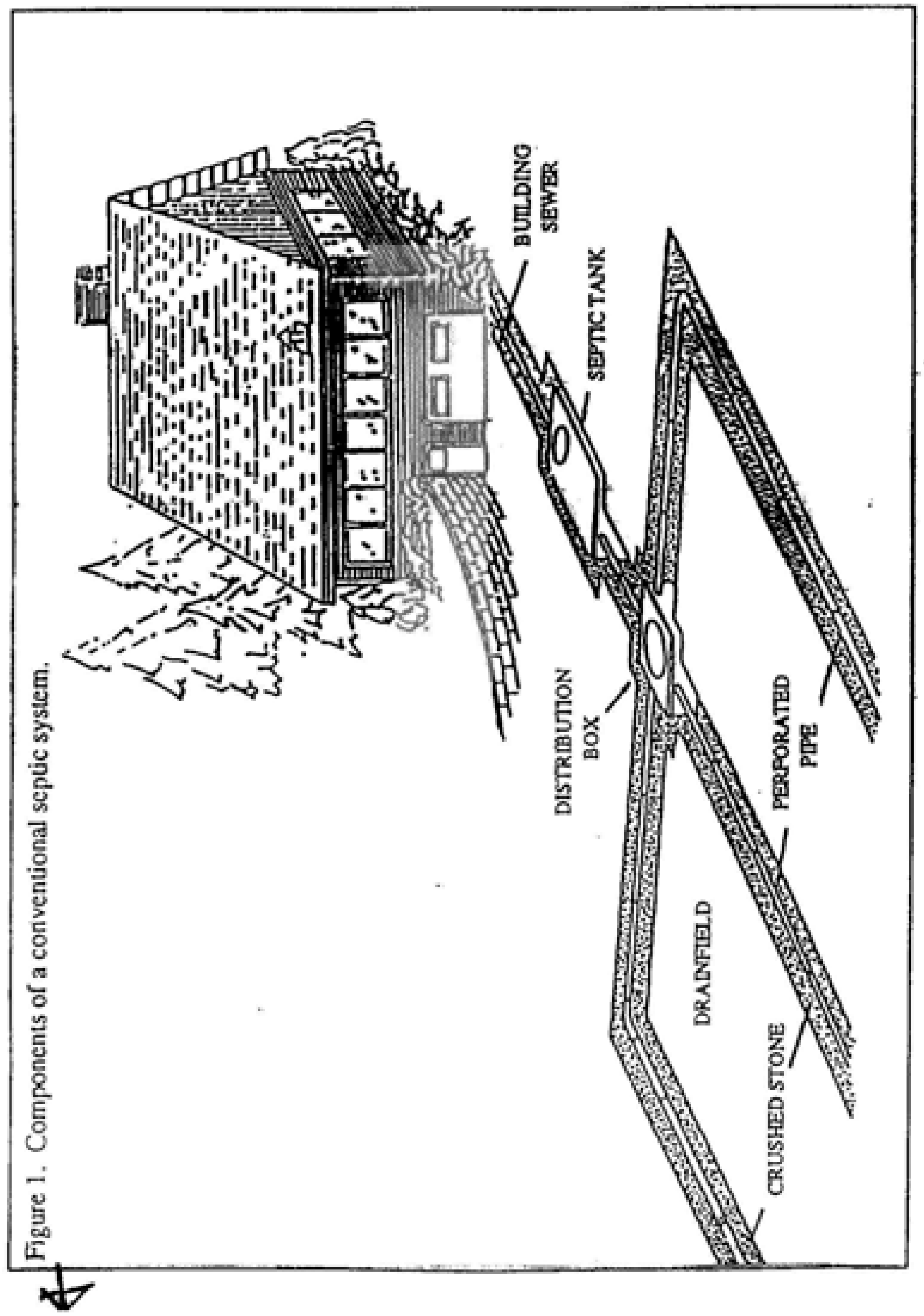


Figure 1. Components of a conventional septic system.

Advanced Treatment Options

Some properties are encumbered with site constraints which preclude the use of a conventional septic system. In such cases an Innovative or Alternative (I/A) system may be considered by the designer. DEM maintains a list of Department approved technologies, for this purpose. This list includes proprietary systems, and system components, manufactured and marketed by a business entity as-well-as non-proprietary sand filters.

Proprietary systems which pass the approval process are issued an approval for a specific use, two examples are TSS and BOD reduction or TSS, BOD and nitrogen reduction. The appropriateness of a technology is a function of the site for which it is proposed. The vendor of the technology is required to provide with the technology a design manual.

Sand filters are not purchased as a complete system from a vendor. The DEM has issued guidance documents presenting proper design, installation and use of these technologies.

Geology and Parent Soils of Rhode Island

The following five pages have been excerpted from “Soils of Rhode Island Landscapes” University of Rhode Island Agricultural Experiment Station Bulletin 429, January 1988, written by William R. Wright and Edward H. Sautter.

SOIL FORMATION

The characteristics of a soil profile are the result of various physical, chemical, and biological reactions. These reactions may be grouped into four broad soil-forming processes which contribute to the differentiation of horizons. These soil-forming processes include additions, removals, transfers, and transformations (16). Additions of organic matter from decaying vegetation are an early step in soil formation. In addition, accumulations of various elements and particles from rainwater or wind occur in most soils. During soil formation there is also a relatively constant removal of soil constituents. Many soluble elements are leached through the soil profile by percolating rainwater, and water running over the soil surface may remove soil particles by erosion. Water percolating through a soil profile may not actually remove elements from the soil completely, but may simply transfer these compounds from one horizon to another. This transfer process may involve the movement of such soil constituents as clay, organic matter, iron, calcium, and magnesium from the A horizon to the B horizon. Transformations or chemical and biological changes of various soil components are continually occurring in soils. Organic matter is readily broken down in most soils and is present in various stages of decomposition. Upon decay it releases numerous humic acids. The inorganic or mineral components of soils are also undergoing continuous change. Although relatively long periods of time are required, primary minerals such as feldspars and micas are transformed to clay type minerals during the weathering process.

It is generally accepted that the soil-forming processes of additions, removals, transfers, and transformations proceed in most, if not all, soils. The relative importance of the various processes, however, differs from one soil to another. The combinations of these processes, as dictated by various factors of soil formation, give rise to specific and unique soils. The five soil-forming factors commonly recognized among soil scientists as controlling the relative importance of the various processes of soil formation and thus the kind of soil that ultimately develops are: parent material, climate, living organisms, topography or relief, and time (7).

These factors work interdependently in producing a particular soil. Differences or similarities between soils are due to differences or similarities in one or more of the soil forming factors. Each factor also modifies, or is modified by, other soil forming factors. For example, topography modifies the effects of rainfall, a climatic factor, by influencing the distribution of water. On steep slopes a greater percentage of the rainwater runs off the soil surface and less of this water percolates through the soil. Conversely, depressions in the landscape not only receive water

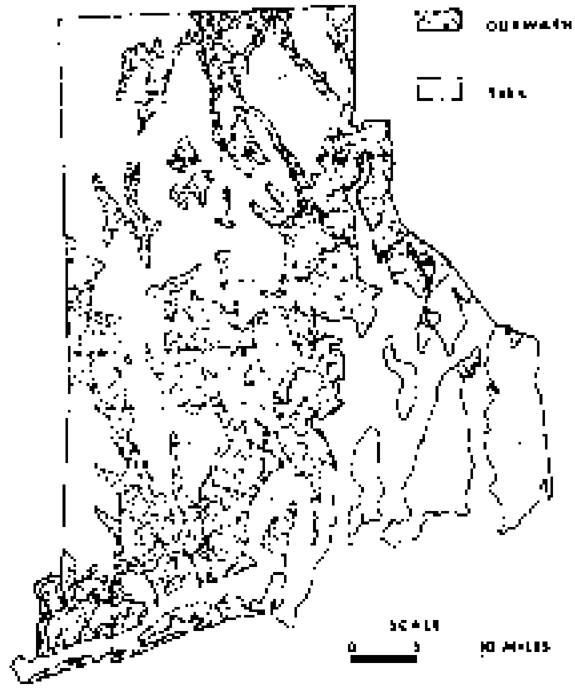


Figure 1. Generalized map showing the general areas of glacial till and outwash in Rhode Island (adapted from Quinn, 1976).

directly as rainfall, but as runoff from higher positions on the landscape. Climatic differences, primarily rainfall and temperature, also influence the type of vegetation present in an area. Therefore, not only does the difference in climate produce a change in soil characteristics, but a change in vegetation, as a result of the climatic change, may result in a different balance of soil-forming processes. It is necessary to study the various factors of soil formation so that variations in soil properties can be explained, as well as predicted, from one place to another. These factors will be discussed in subsequent sections in greater detail as they relate to Rhode Island soils.

Parent Material

The initial step in the development of a soil profile is the formation of soil parent material. The unconsolidated residue resulting from the physical and chemical weathering of various types of bedrock is called parent material. Some soils have formed from the weathering of bedrock in place, however, most of the soils in Rhode Island have formed from material that was transported from the site of the parent rock and redeposited at the new location through the action of ice, water, wind, or gravity.

Glacial ice was particularly important in transporting and depositing the parent materials from which Rhode Island soils developed. During the

Pleistocene or Ice Age, a very large mass of glacial ice moved down from Canada and covered the entire state. The ice moved like a giant bulldozer across the landscape and pushed along pre-glacial soil, plucked boulders out of the bedrock, and ground rocks into smaller particles. Hills were leveled and streamlined in the direction of the ice movement and some valleys were deepened. Approximately 10,000 years ago the climate warmed and the ice melted, filling many of the valleys with glacial debris. Subsequently, winds blowing across the unvegetated glacial sediments picked up silt and fine sand particles and redeposited them elsewhere on the landscape to form what is called loess.

The parent material not only provides a framework for the soil, but influences to a great degree the physical, chemical, mineralogical, and morphological characteristics of the soil. The principal parent materials of Rhode Island are glacial till and glacial outwash (Figure 3). A small percentage of the soils in Rhode Island have also developed from organic deposits or loess-covered glacial drift.

Approximately 65 percent of the soils in Rhode Island have developed from glacial till. Glacial till is the unsorted mixture of clay, silt, sand, gravel, and boulders which was directly deposited by the ice sheet. The glacial tills from which Rhode Island soils were formed are primarily loamy sand and sandy loam of acid crystalline rock origin. Thus most of the soils are medium to coarse textured. The area of glacial till located east of Narragansett Bay and along a narrow strip on the west side of the Bay originated from carboniferous slates and shales. The soils derived from these carboniferous deposits are, for the most part, dark colored and silt loam in texture. Most of the glacial till in Rhode Island is located on gently sloping and rolling uplands and drumlins. The landscape is characterized by numerous boulders and stone walls. Because of limitations for farming most of these areas remain forested.

Approximately 20 percent of the soils in Rhode Island have developed in glacial outwash deposits. As the ice sheet melted during warm periods, melt water flowed from the margins of the glacier and carried with it a large amount of sediment. This sediment became sorted and was redeposited as stratified layers of gravel, sand, and silt. Most of the outwash in Rhode Island is in broad valleys which are called outwash plains. These areas are relatively flat and free of stones and boulders and are generally considered to be some of the best soils for farming in the state.

Loess is a silty, wind-deposited material which makes up approximately ten percent of the land area in Rhode Island. Loess deposits originated from materials laid down on outwash plains as a result of glacial melt water. After drying, they were picked up by the wind and redeposited over the landscape. The thickness of loess deposits in Rhode Island ranges from 6 inches to more than 4 feet and averages about 30 inches. These deposits of loess overlie both glacial outwash and glacial till. They have high water holding capacities and relatively few stones or boulders and make excellent soils for agricultural use.

Organic deposits form the parent materials for peat and muck soils which occupy approximately five percent of the land area in Rhode Island. These organic deposits generally occur in small, very poorly drained depressions. The wet environment has retarded the decay of organic matter which has accumulated over time. The thickness of the organic deposits ranges from less than one foot to more than 20 feet. Most of the salt marshes, which occur along the coast, have less than 16 inches of organic material over sand. They occupy only about one percent of the land area in Rhode Island.

Climate

Climate, through its component elements (precipitation, temperature, humidity, and seasonal variability), directly and indirectly influences soil development. Direct effects include the influence of temperature and precipitation upon the weathering of rocks and minerals. High temperatures and high rainfall encourage rapid weathering of soil parent materials. In areas of low rainfall or low temperatures, however, the weathering processes are very slow and the soils have little development.

Climate also plays an indirect role in the formation of soils through its effect upon plant growth and adaptation. These influences are more pronounced on a world-wide or nation-wide basis where climate dictates to a great degree whether the dominant vegetation is grassland, deciduous or conifer forest.

Although Rhode Island is small in total land area, the weather varies widely between localities (3). Rhode Island's climate is humid and temperate, and the growing season generally ranges from about 130 to 180 days. Because of the proximity of the ocean and of Narragansett Bay, the climate is modified and warmed in winter and correspondingly cooled in summer. The effect of these maritime air masses is particularly evident on Block Island which has a frost-free period exceeding 200 days a year.

The average annual temperature at Kingston, R.I., is 49.5 F (9). On the average there are only about four days a year with a high temperature of over 90 F, though there is a great deal of variation from year to year. During the winter months, the daily maximum is usually well above freezing and there are, on the average, only 20 days a year without significant afternoon thawing. While the daily minimum is below freezing on all but 12 days during the average winter, below zero readings occur only four days a year. The normal maximum, mean and minimum temperatures at Kingston, R.I., during the year are presented in Figure 4.

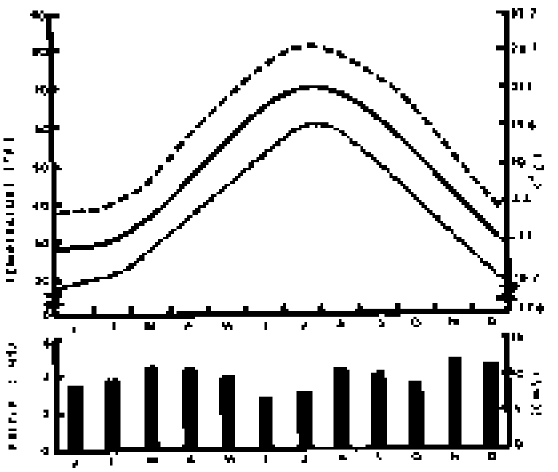


Figure 4. Average daily maximum and minimum temperatures and average monthly temperature and rainfall for Kingston, Rhode Island (1951-1978)

Precipitation is highly variable from year to year and the probability of any one year being four or more inches below normal is about one in four. In addition, the range in precipitation between measuring stations in Rhode Island is reported as a little over 4 inches (5). Seasonal snowfall averages 42.6 inches and most of it occurs during the months of December through March. The average annual rainfall at Kingston, R.I. is 48.07 inches (9). The monthly distribution of rainfall in Rhode Island is fairly uniform; however June and July are the driest months. Figure 4 shows the monthly distribution of rainfall at Kingston.

Living Organisms

The role of living organisms (flora and fauna) in soil formation is extremely important. Although microorganisms and other soil fauna play a major role in the decomposition of organic matter and availability of nutrients, the importance of vegetation is perhaps more evident in soil genesis. The type of vegetation growing in an area is determined primarily by the climate, soil parent material, relief, drainage, and age of soil or landscape. There are approximately 425,000 acres of uncleared forest land in Rhode Island, which makes up about 70 percent of the total land area in the state (8). The state's most important forest land category in terms of area is hardwoods. The hardwoods, located on well drained upland sites, generally include black oak, red oak, white oak, scarlet oak, and red maple. Less common trees in hardwood stands are American beech, chestnut oak, and various species of birch, cherry, aspen, and ash. Hardwood forests associated with poorly and very poorly drained sites consist mainly of red maple, red ash, and swamp white oak. These sites usually have a dense shrub layer that includes species such as laurel, azalea, sweet pepperbush, spice bush, and wetland herbs such as hellebore and skunk cabbage.

Softwood forests make up only about three percent of the total land area of the state (8). In upland sites the common tree species are white pine and pitch pine. In the more poorly drained areas and swamps, black spruce and Atlantic white cedar are present along with some hemlock.

The tidal marshes and freshwater marshes comprise about 5 percent of the land area in the state. Some plants characteristic of salt marshes are cordgrass, saltgrass, and various sedges and rushes. The plant composition of freshwater marshes is strongly influenced by water depth. The shoreline of marshes is characterized by cattail, pickerel weed, and burreed while in water three to four feet deep, pond weed, bladderwort, and coontail are common.

Microorganisms also play an important role in soil formation. They are a source of organic matter and aid in the decomposition of fallen leaves and dead organisms. These oxidized or decomposed organic materials are called humus. Only small amounts of humus are needed to influence the character of a soil. An average mineral soil in Rhode Island contains about four to six percent organic matter in the A horizon, but this small amount greatly influences such soil properties as nutrient content, aggregation, and water holding capacity.

The type of vegetation not only determines the amount of organic matter in the soil, but modifies many of the soil's chemical, physical and morphological properties. Nearly all of the nitrogen and a large portion of the phosphorus and sulfur are contained in organic fractions. In addition, soils formed under deciduous vegetation are usually not as acid as those formed under conifers. The residue of deciduous plants generally contains larger amounts of basic elements, such as calcium and potassium, than residue from conifers, and therefore, there is a greater degree of nutrient cycling. Soils developed under deciduous plants also tend to have thicker A1 horizons and greater microbial populations.

Human activity also greatly influences soil development. Although we may improve some soils through various practices such as liming, fertilizing, and drainage, most of our activities are destructive in terms of soil formation.

Topography

Topography, or relief, generally denotes the configuration of the land surface. It affects the formation of soils primarily by altering the distribution and movement of water. Topographic position also affects soil temperature, parent material character, and type of vegetation. A number of soil properties are related to relief or landscape position and include such things as thickness of solum, thickness and organic matter content of the A horizon, soil color, reaction, soluble salt content, degree of horizon differentiation, and presence or absence of dense, compact layers.

One of the most obvious relationships of topography to a soil property is that nearly level soils tend to have thicker sola than those on slopes. This can usually be attributed to slow erosion of the soil material on slopes and its subsequent deposition in depressions. As a result of this increased runoff on slopes, there is also less percolating water to weather the parent material and form soil. Both of these processes are perhaps important in considering the relationships between solum thickness and relief.

Not only is the degree of slope important in soil genesis, but also the slope aspect. In the temperate regions of the world, south-facing slopes are generally drier and warmer than north-facing slopes. Thus soils on south-facing slopes are generally lower in organic matter, contain fewer microorganisms, and have more mature profiles. In addition, the vegetation on south-facing slopes consists of species adapted to drier and warmer environments.

The relationship of topographic position to type of parent material is an important and obvious association in Rhode Island. The broad, flat valleys, termed outwash plains, are composed primarily of water-worked, stratified sand and gravel. These outwash

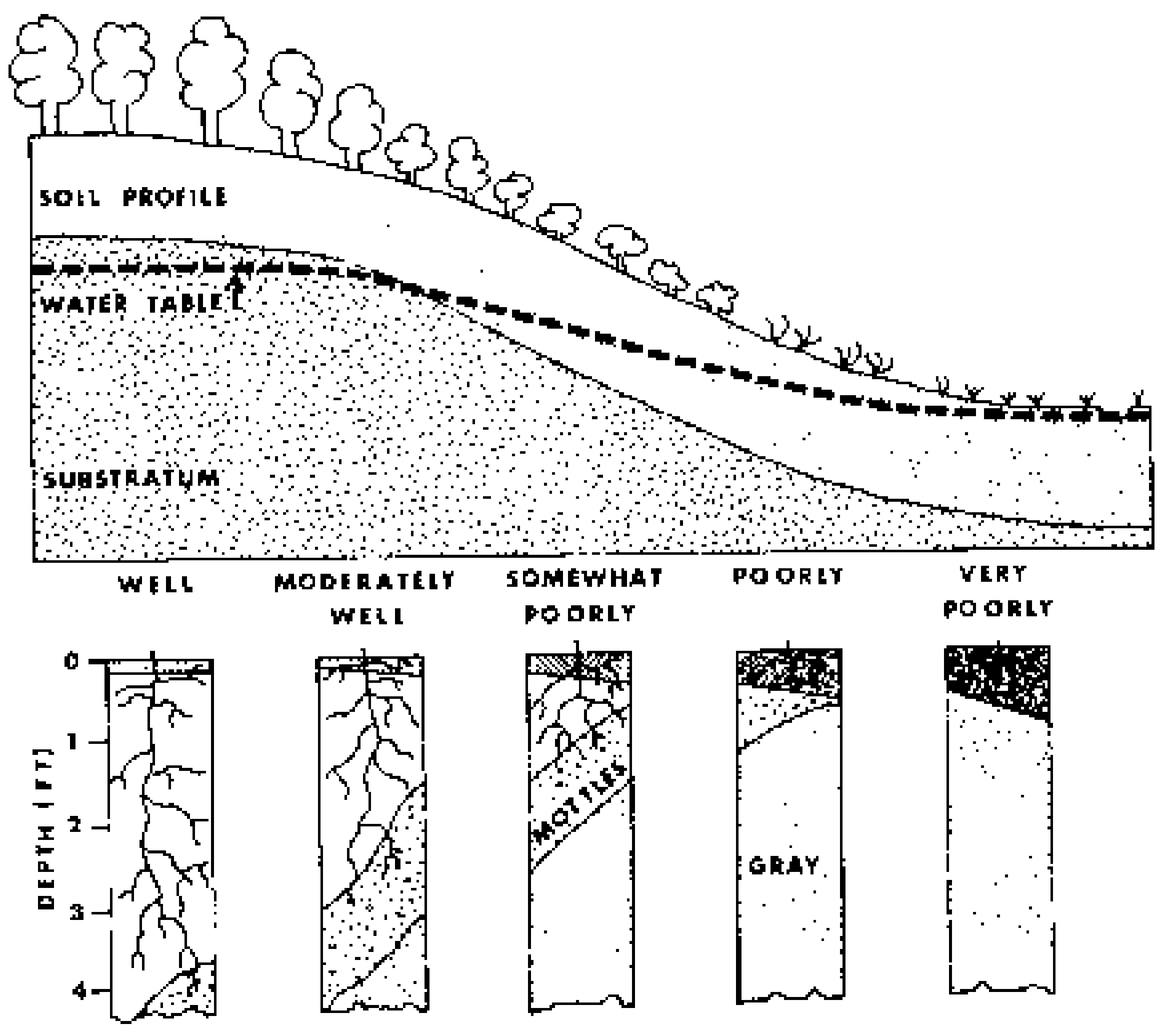


Figure 5. Schematic representation of a soil toposequence or catena

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deposits are essentially stone-free and are commonly capped with a windblown silt deposit called loess. Most of these areas are being farmed. The more rolling topography associated with most of the Rhode Island landscape is composed of glacial till. Boulders are generally quite prevalent in these areas and the dominant land use is forestry.

Perhaps the most important soil-landscape relationship in Rhode Island is that associated with water tables or internal soil drainage. As illustrated in Figure 5, soil profiles are more strongly developed and deepest on the higher portions of the landscape. The more poorly drained soils, which are at lower positions or in depressions on the landscape, generally have thick, dark surface horizons and the subsoils are speckled or mottled with gray colors. These poorly and very poorly drained soils are saturated with water for much of the year and are slower to warm up in the spring. The cool temperatures and low oxygen supplies associated with these wet conditions retard microbial activity, thus resulting in a buildup of organic materials. These low-lying wet soils also tend to have higher base saturations, as nutrients have accumulated from runoff water from higher positions on the landscape.

Although the soil toposequence illustrated in Figure 5 is the classical example, it is not uncommon to find wet, poorly drained soils in upland positions on the landscape. Many of Rhode Island's soils on uplands are underlain by dense, compact glacial till which can result in perched water tables.

Relief is perhaps the single most dominant factor influencing the different kinds of soils in Rhode Island. A knowledgeable, well-trained soil scientist can readily identify soil-landscape relationships. These concepts are perhaps the most valuable in preparing accurate, useful soil maps.

Time

The degree of profile differentiation is dependent not only on the intensity of the soil-forming processes, but also on the duration of these processes. The amount of time may vary from a few days for fresh alluvial deposits to several hundreds of thousands of years for old stable landscapes. In terms of soil formation, the soils of Rhode Island are relatively young. The ages of the soils in Rhode Island are mainly related to the ages of the glacial deposits. Most of the glacial drift in southern New England has been correlated with the Wisconsin glacial period [13]. The maximum advance of the ice sheet occurred approximately 20,000 years ago. Nearly 5,000 years elapsed during the retreat of the ice sheet which was followed by a periglacial climate in which a great deal of wind-blown silt (loess) was deposited on the landscape. Therefore, it is generally agreed that the oldest soils in Rhode Island are in the neighborhood of 10,000 to 15,000 years old.

It is more reasonable, however, to speak of the age of soils in terms of their state of maturity, rather than in years. The terms "young," "mature," and "old age," which were originally developed for the description and identification of landscapes have been applied to soils. The estimate of relative age or degree of maturity of soils is universally based on horizon differentiation. In practice, it is accepted that the larger the number of horizons and the greater their thickness and expression, the more mature the soil.

The comparatively young soils in Rhode Island have horizons that are weakly developed except for the addition of organic matter to topsoils and the development of color in B horizons. The soils of recent alluvial origin are even less mature than those formed in glacial drift. Many of these soils continue to receive sediment which has been eroded from the surrounding uplands and their morphological properties are not unlike the parent material, since soil-forming processes have not had time to alter this fresh material.

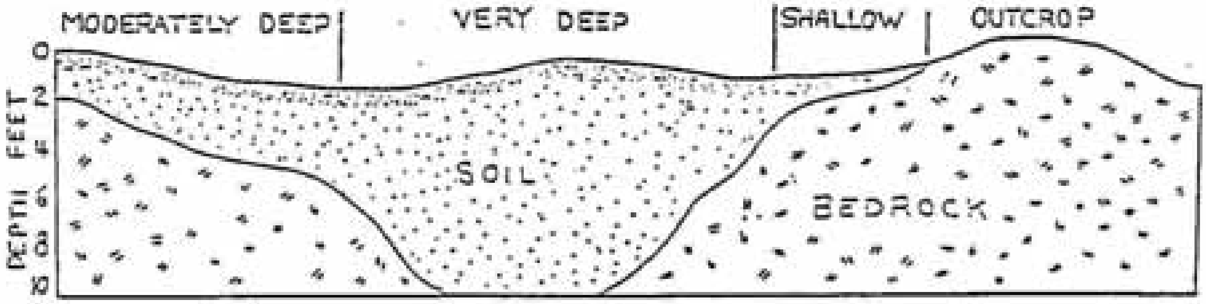
Mature soils are those which have attained maximum horizon differentiation and are in equilibrium with their environment. As a result of the relatively young glacial landscapes in Rhode Island, the soils have not yet reached this degree of maturity. Although the processes of soil formation are extremely slow, it is possible that the soils of Rhode Island could change drastically over the centuries as they approach equilibrium with their environment.

Summary

Soil thinly mantles the earth's surface and is a dynamic natural body. It has been produced by numerous physical and chemical processes acting upon geologic materials. Soil formation is a continuing process and the nature of the soil formed is dependent upon the parent material, climate, living organisms, relief, and time of weathering. None of these factors acts independently, but each modifies the effects of the others. It is the interaction of these five factors of soil formation that has resulted in the formation of the more than 100 types of soil in Rhode Island.

FIELD IDENTIFICATION OF SOILS IN MASSACHUSETTS
BY P.C. FLETCHER

I. <u>SHALLOW TO BEDROCK AREAS:</u> Generally in Massachusetts these areas are a complex of rock outcrops (surface exposers of bedrock), shallow to bedrock soils (10-20"), moderately deep to bedrock soils (20-40"), and very deep soils (>60").



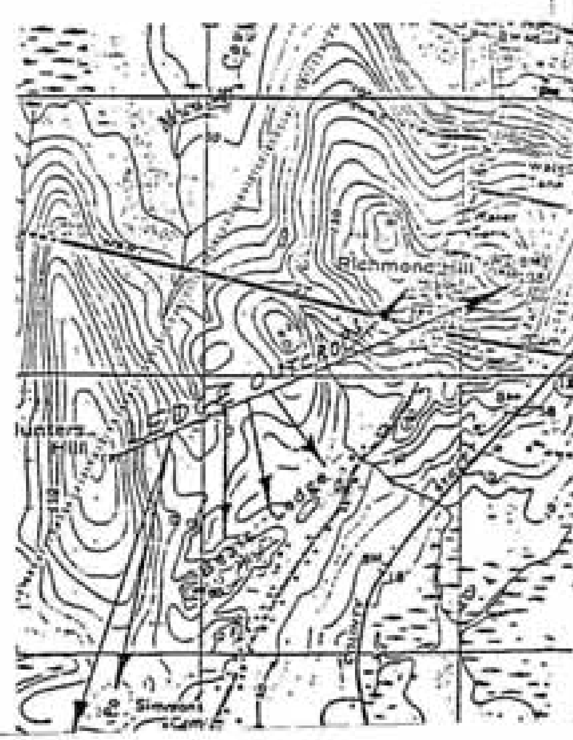
Cross section of shallow to bedrock soils

A. Field Identification of Shallow to Bedrock Areas.

1. Landform - No distinguishing landform, often marked by irregular shaped knolls and steep ridges.

2. Test Pit
   a) presence of bedrock outcrops in adjacent areas.
   b) bedrock within the test pit.

3. Identification of shallow to bedrock areas from a U.S.G.S. topographic quad sheet.



II. GLACIAL TILL: definition - Dominantly unsorted and unstratified mineral material, deposited by and underneath a glacier, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, cobbles, stones, and boulders.

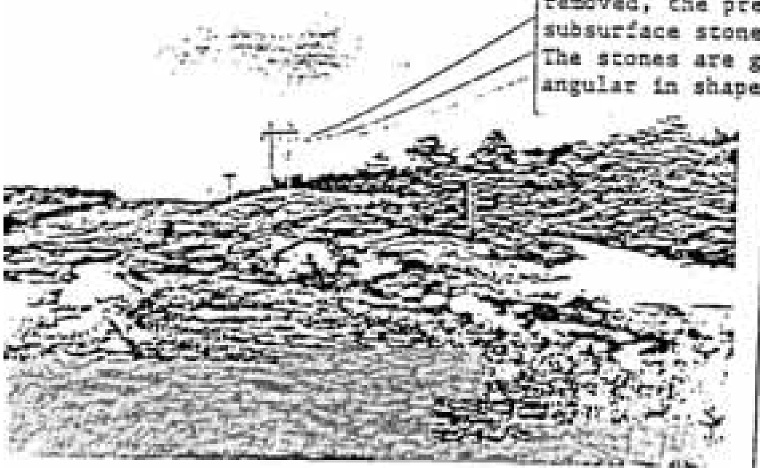
A. Types of Glacial Till

1. Loose sandy and gravelly till (Ablation till): Loose, permeable, sandy and gravelly till deposited during the final downwasting of nearly static, melting glacial ice. Lenses of crudely sorted sand and gravel are common. Except for stones and boulders, loose till is difficult to separate from ice-contact glacial outwash.

2. Compact, dense glacial till (Lodgement till): Compact, dense, loamy and silty till deposited by advancing glacial ice. Soils developed in this parent material are generally friable, and permeable in the upper 2 to 3 feet and are underlain by firm, slowly permeable compact glacial till (hardpan).

B. Field Identification of Glacial Till Areas

1. General appearance - All glacial tills in Massachusetts have varying degrees of surface and subsurface stones. If the surface stones have been removed, the presence of stone walls and subsurface stones indicate till areas. The stones are generally angular or sub-angular in shape.



2. Landform

a) Drumlin —A low, smooth, elongated oval hill of compact glacial till that may or may not have a core of bedrock. The longer axis is parallel to the general direction of glacier flow. Drumlins are products of streamline flow of glaciers which molded the subglacial floor through a combination of erosion and deposition.

b) Till ridge - similar to a drumlin except it is more elongated and is a ridge rather than a hill.

c) Moraines - An accumulation of drift, with an initial topographic expression of its own, built chiefly by the direct action of glacial ice. Examples are end, ground, lateral, recessional, and terminal moraines.

Moraine (recessional) - An end moraine, built during a temporary but significant halt in the final retreat of a glacier.

Moraine (terminal) - An end moraine that marks the farthest advance of a glacier and usually has the form of a massive arcuate ridge, or complex of ridges, underlain by till and other drift types.

d) Ground moraine - Till area with no typifying topographic expression, generally undulating, low lying hills.

3. Soil Pit

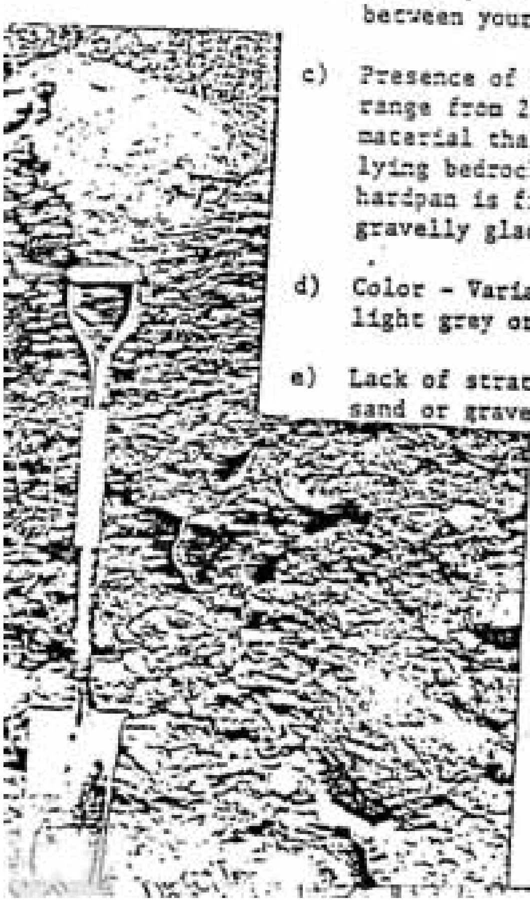
a) Presence of angular and subangular cobbles, stones and boulders within the face of the pit.

b) Soil texture in the substratum (approximately below 33") - Can be very variable and may range from loamy sand to silt loam. There is almost always enough silt and clay present to dirty the pores of your palm when a dry sample is rubbed between your hands.

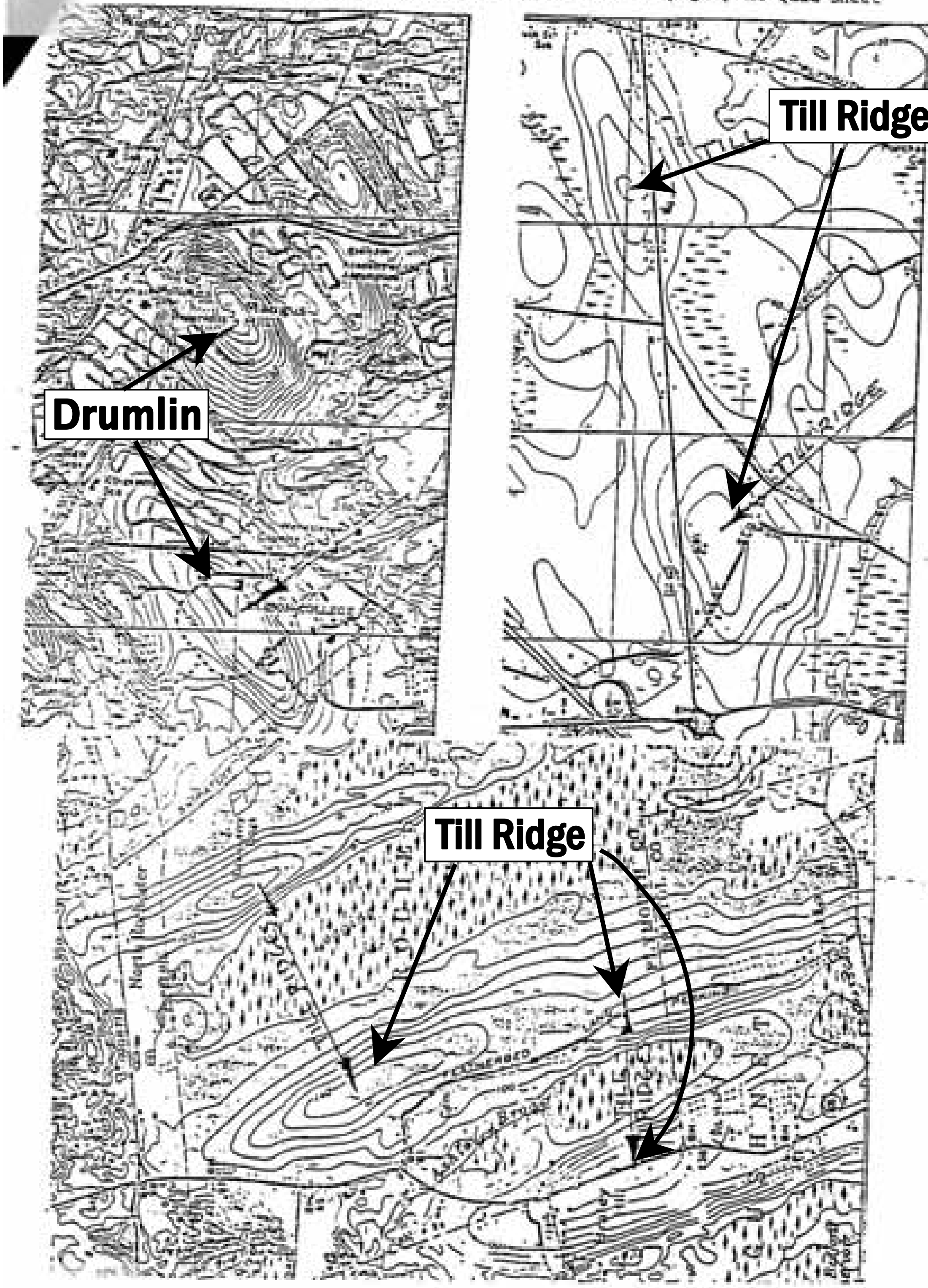
c) Presence of hardpan - Depth to hardpan is variable and may range from 20 to 40 inches. It is firm, slowly permeable material that is generally continuous with depth to underlying bedrock (it is not a thin layer). In Massachusetts, hardpan is firm compact glacial till. Loose, sandy, and gravelly glacial till does not have a hard pan.

d) Color - Variable, in southeastern Massachusetts, it is light grey or olive in the substratum.

e) Lack of stratification - There are no distinct layers of sand or gravel.



4. Identification Of Till Areas From a USGS Topographic Quad Sheet



II. <u>GLACIAL OUTWASH</u>: definition - Stratified sand and gravel produced by glaciers and carried, sorted, and deposited by glacial melt water streams.

A. Field Identification of Glacial Outwash Areas

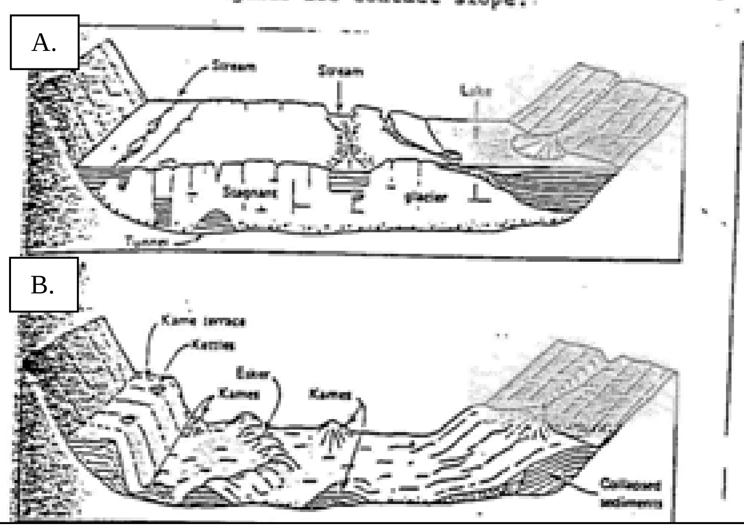
1. Landform

a) Outwash Plain - Generally, a broad, nearly level plain deposited by meltwater streams as they flowed out beyond the ice terminous. Most outwash plains have some steep sided depressions (kettle holes) or lakes (kettle lakes) resulting from where the outwash was deposited around and over stagnant ice, which later melted out leaving a depression.

b) Esker - A long, narrow, sinuous, steep-sided ridge composed of irregularly stratified sand and gravel that was deposited by a subsurface stream flowing between ice walls or in an ice tunnel of a retreating glacier, and was left behind when the ice melted. Eskers range in length from less than a quarter mile to more than a mile, and in height from 15 feet to 75 feet.

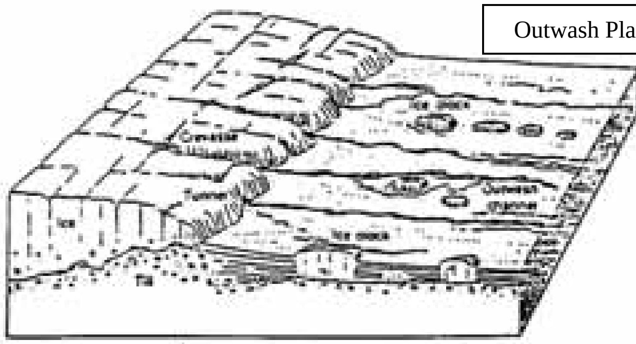
c) Kame - A moundlike hill of ice-contact glacial drift, composed chiefly of stratified sand and gravel.

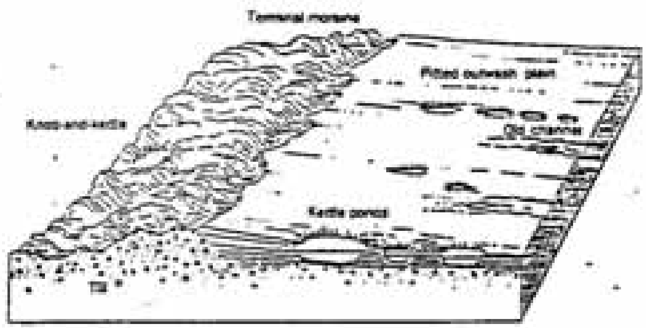
d) Kame Terrace - A terrace-like ridge consisting of stratified sand and gravel deposited by a meltwater stream flowing between a melting glacier and a higher valley wall and left standing after the disappearance of the ice. It is commonly pitted with "kettles" and has an irregular ice-contact slope.



Origin of bodies of ice-contact stratified drift.
A. Stagnant glacier ice affords temporary retaining walls for bodies of sediment built by streams and in lakes.
B. As ice melts, bodies of sediment are let down and in the process are deformed.

Outwash Plain

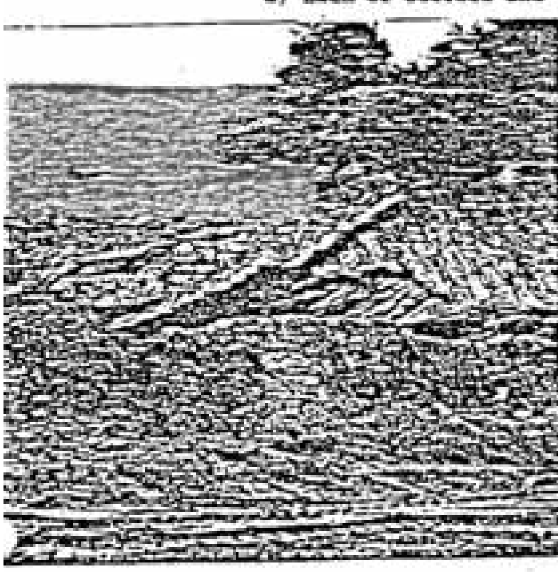




2. General Appearance - Almost always free of surface stones, depending on the landform has a variety of different topographic expressions.

3. Soil Pit

a) Lack of surface and subsurface stones and boulders - A few stones may be present on the ice-contact faces of some eskers and kames. Generally, the largest rock fragments found in outwash are rounded and subrounded cobblestones.



b) Sandy or gravelly substratum - Generally, within a depth of 24 to 36 inches there is clean, loose, sand, or gravel (very little silt and clay, when rubbed in hands will not dirty pores). Most often it is stratified or layered.

4. Identification of outwash areas from a U.S.G.S. topographic quad sheet.

IV. GLACIAL LAKEBED (Lacustrine) SEDIMENTS: definition - Fine textured, silty and clayey material deposited in glacial lakes by water originating mainly from the melting of glacial ice. Many are bedded or laminated with varves (thin, alternating layers of silt and clay).

A. Field Identification of Glacial Lakebed Areas.

1. Landform - No distinguishing landform, generally nearly level or undulating areas.

2. Test pit

a) Lack of coarse fragments - Generally, no gravel, cobbles or stones.

b) Soil texture - Generally, a high percentage of silt and clay. Soil texture is generally loamy very fine sand or finer.

Silt
Clay
Silt
Clay

c) Varved substratum - Often deep within the profile, varves are present. Marine silts and clays, common to Northeastern Massachusetts are not varved.

3. Identification of glacial lake bed sediments from a U.S.G.S. topographic quad sheet.

V. <u>ALLUVIAL (STREAM) SEDIMENTS:</u> definition - Material deposited by streams and rivers, including gravel, sand, silt, clay, and various mixtures of these.

A. Field Identification of Alluvial Deposits

1. General Appearance -
   a) Areas extensive enough to be shown on a soils map are only located adjacent to major rivers.

   b) Level to nearly level areas adjacent to large streams and rivers.

2. Landforms
   a) Floodplain - The nearly level alluvial plain that borders a stream and is subject to inundation under flood-stage conditions unless protected artificially. It is usually a constructional landform built of sediment deposited during overflow and lateral migration of the stream.

   b) Backswamp - Extensive marshy, depressed areas of flood plains between the natural levee borders of channel belts and valley sides or terraces.

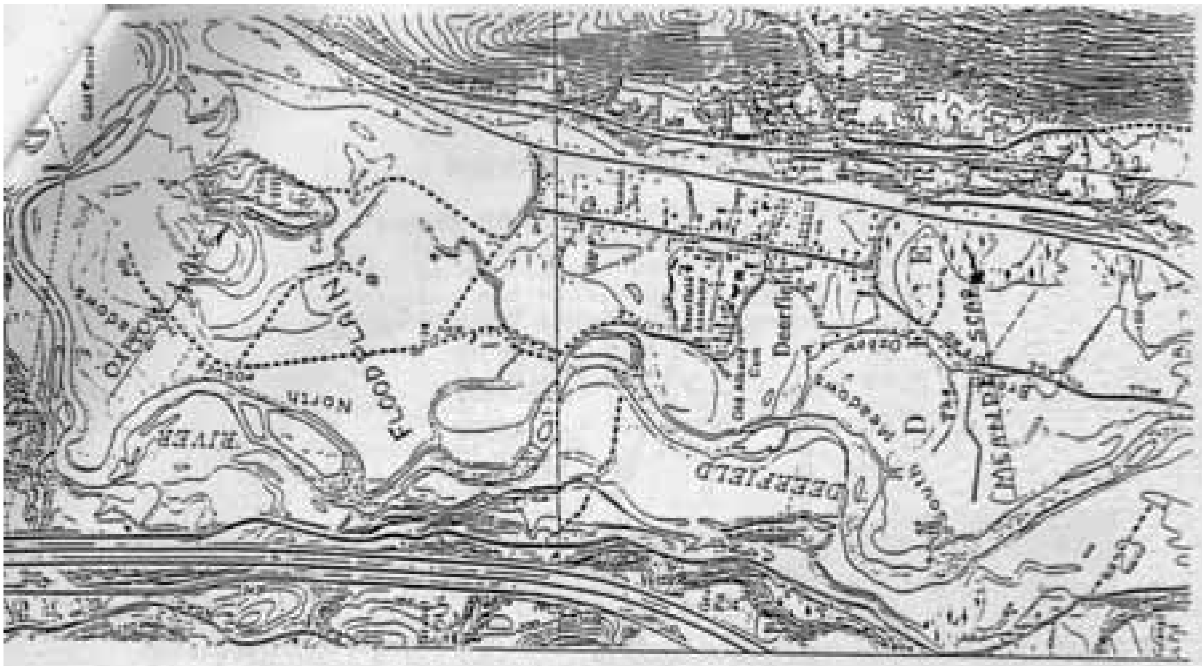
   c) Oxbow lake - The crescent-shaped, often ephemeral, body of standing water situated by the side of a stream in the abandoned channel (oxbow) of a meander after the stream formed a neck cutoff and the ends of the original bend were silted up.

3. Soil Pit
   a) Lack of profile development - These are very recent geologic deposits and lack most profile development. Generally, a dull, darkish color throughout. Often haved buried surface horizons.

   b) Soil texture - Depending upon the water velocity; textures vary from gravel to silt, most being fine sandy loam or finer.

   c) Stratification - May have some fine stratification in the substratum.

4. Identification of alluvial areas from a U.S.G.S. topographic quad sheet.



VI. <u>ORGANIC DEPOSITS</u> - definition of organic soil - Greater than 15 inches thick and having more than 20 percent organic matter (as opposed to mineral material).

A. Field Identification of Organic Soil Areas

1. Landform - Level, very poorly drained areas within depressions, at the base of swales, and adjacent to water bodies.

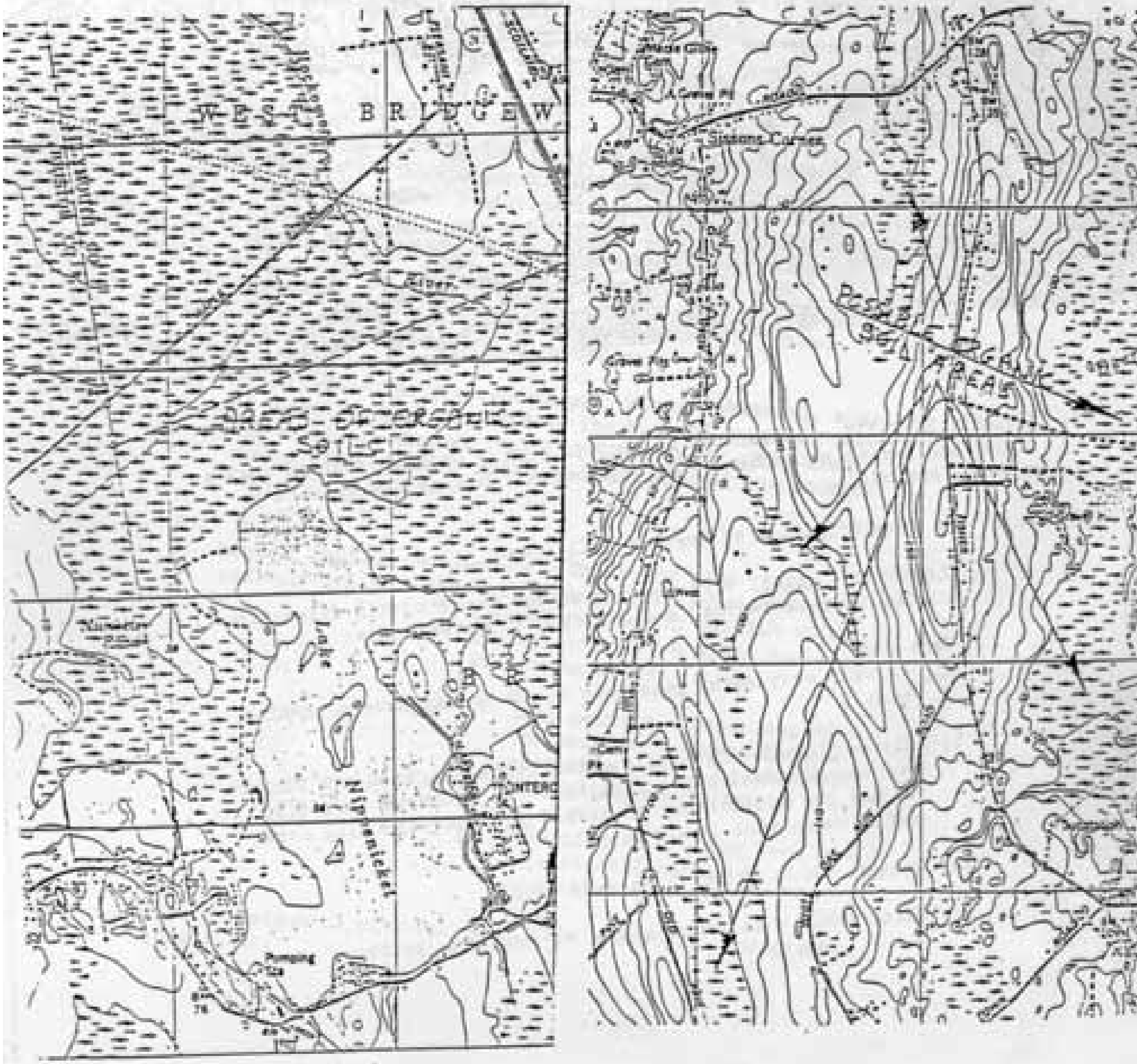
2. Test Pit
   a) Color - very dark, generally black or may have a reddish hue.

   b) Slippery feel - Generally, when rubbed between the fingers you can not feel any grittiness. If squeezed in a fist, it has the consistency of mashed potatoes and will ooze out between your fingers.

   c) Weight - When dried it is very light.

   d) Water table - Is generally at or near the surface.

3. Identification of organic deposits from a U.S.G.S. topographic quad sheet.
Most often, the areas on a topo sheet that have marsh symbols ( ) are organic soil areas.

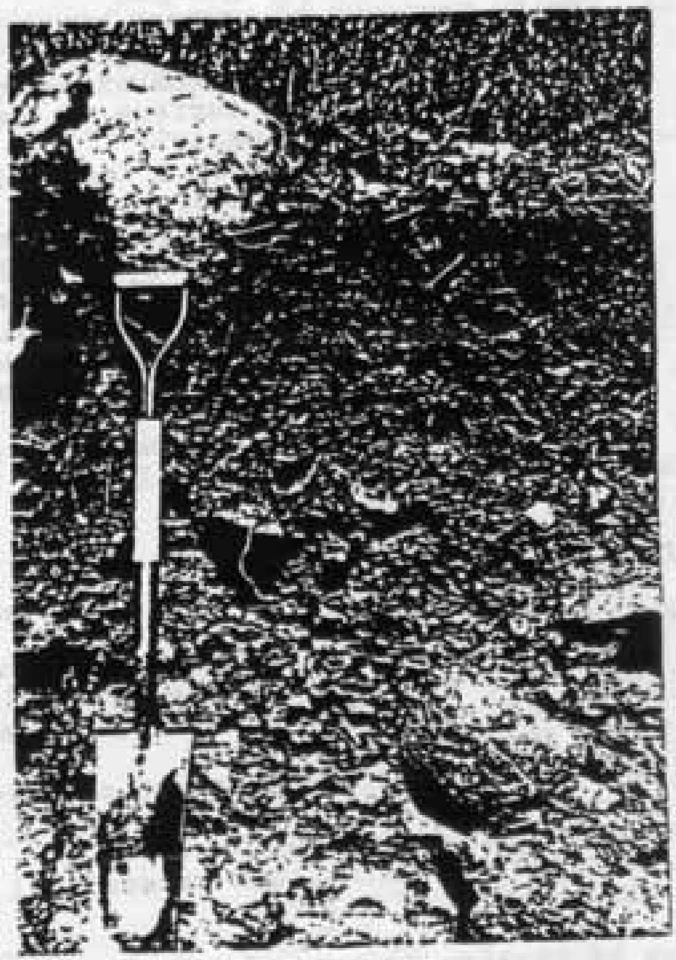


GEOLOGIC DEPOSITS

There are eight broad groupings of geologic sediments (soil parent material) which occur within Massachusetts. Knowing the geology of a site is crucial to understanding how a site will impact adjacent areas and will help to narrow the focus of an on-site investigation to key issues.

GLACIAL TILL

Definition: Dominantly unsorted and unstratified debris deposited by a glacier; consisting of a heterogeneous mixture of clay, silt, sand, gravel, stones, and boulders.



Kinds: Two broad groupings of till:

1. Compact till also referred to as dense basal till or lodgement till
2. Loose, sandy till also referred to as ablation till

Compact Till

Characteristics:
1. Wide particle size distribution: clay, silt, sand, gravel, cobbles, stones and boulders
2. Unsorted, heterogeneous mixture
3. Angular shaped rock fragments
4. Substratum, firm and compact (locally referred to as hardpan)
5. Relatively high percent clay (7 - 25%)

Associated Landforms:
1. Drumlin
2. Till ridge
3. Ground moraine

Focus of On-Site Investigation:
1. Verify presence of compact substratum. Field method for identifying compact till:
   a. Note the ease of excavation by backhoe, a bucket often chatters across surface of compact till making shallow cuts with each pass.
   b. Pick at the side of a test hole with a knife to feel for ease of penetration.
   c. Squeeze a clod of soil between your thumb and index finger, initially compact till will resist crushing and then with increased pressure rupture suddenly.
2. Conduct perc test in the most limiting layer
3. Check for the presence of a perched water table
4. Avoid construction during wet periods, may cause soil smearing and compaction
5. If several areas fail to perc and one passes, determine the extent of suitable material

Sandy, Loose Till (Ablation)

Characteristics:
1. Coarse textured, sandy, gravelly and stony
2. Typically loose, permeable material
3. VARIABLE, often has lenses or pockets of silty material
4. Many stones and boulders
5. Small but significant amount of silt and clay

Associated Landforms:
1. Moraines: terminal and recessional
2. Ground moraine

Focus of On-Site Investigations
1. Determine variability and extent of soil conditions
2. Document any restrictive layers
3. Avoid construction during wet periods, may cause soil smearing and compaction

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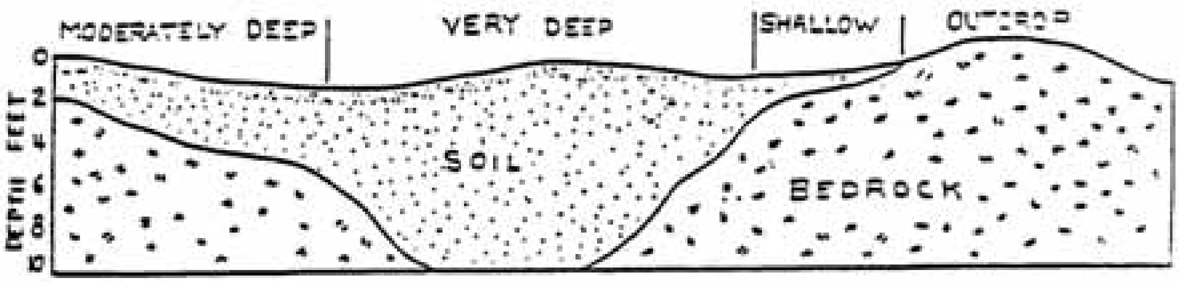
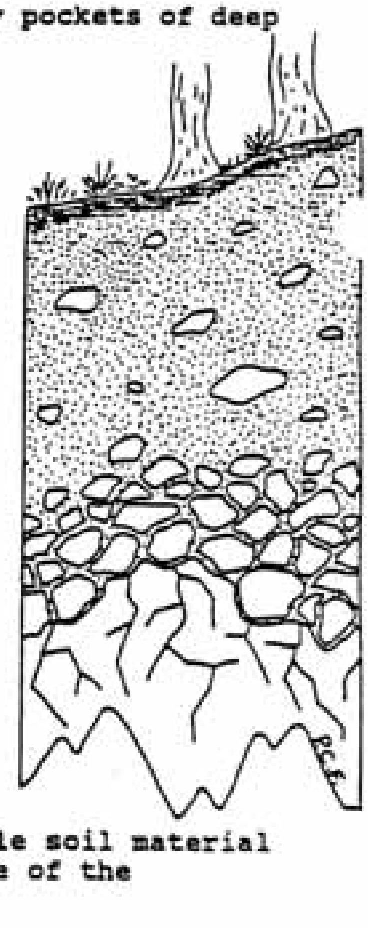
SHALLOW TO BEDROCK AREAS



Complex soil conditions within a shallow to bedrock soil area.



Characteristics:

1. VARIABLE, complex soil conditions, typically pockets of deep soil and areas of shallow to bedrock soils
2. Depth to bedrock often varies over short distances
3. Weathered or fractured bedrock can often be excavated easily but is not considered suitable material for a leaching facility
4. Rippable or non rippable with an excavator

Associated Landforms:

1. Bedrock areas are not associated with any particular landforms
2. Typically bedrock areas are associated with irregular terrain, steep ridges, abrupt KNOBS - however, some areas of bedrock are nearly level to gently rolling with few outcrops of ledge.

Focus of On-Site Investigation:

1. Due to variable site conditions, the deep hole should be located in the exact location of the proposed facility
2. Maintain 4 foot separation of suitable soil material between leaching facility and bedrock surface
3. Fractured bedrock is not considered a suitable soil material and the depth to bedrock is the upper surface of the fractured zone.

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GLACIAL OUTWASH

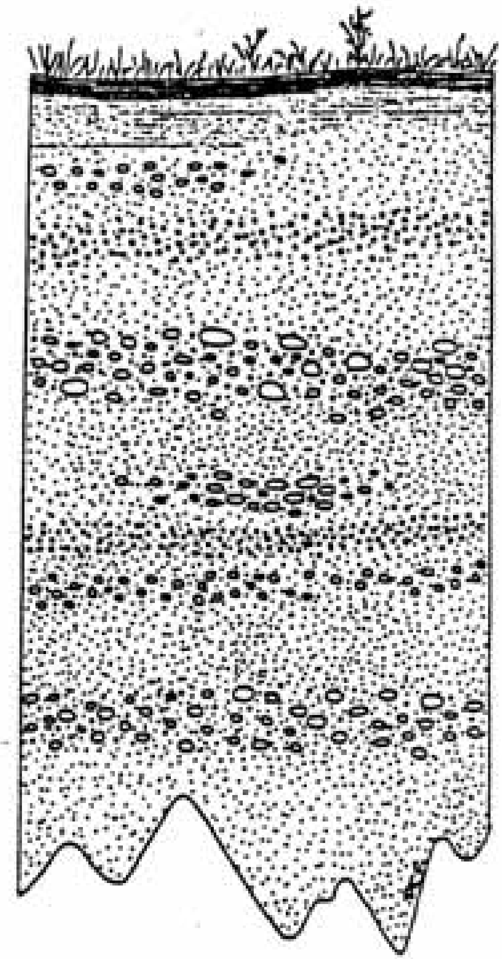
Definition: Stratified deposits of sands and gravel deposited by melt - water streams that flowed from melting glaciers.

Kinds: Two broad groupings of outwash
1. Proglacial outwash - stratified outwash deposited in front of or just beyond the outer limits of a glacier

2. Ice-contact outwash - sands and gravel originally deposited adjacent to stagnant glacial ice, that collapsed when the ice melted leaving an irregular, often hilly terrain

Proglacial Outwash

Characteristics:
1. Stratified, well sorted material
2. Clean sands and gravel, typically with very little silt and clay
3. If present, gravel and cobble size rock fragments are rounded or sub-rounded
4. Loose material, walls of pit slough in
5. Generally lacks stones and boulders

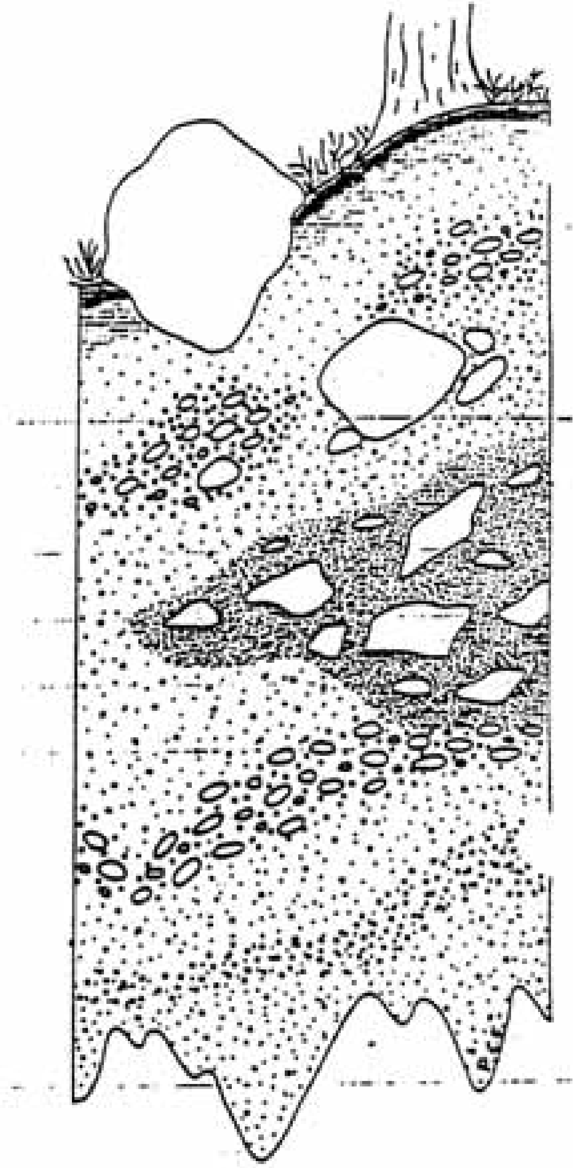


Associated Landforms:
1. Outwash plain

Focus of On-Site Investigation:
1. Rapid to very rapid perc rates
   CAUTION - if areas of these soils are extensive and thick, they are groundwater recharge areas and may be underlain by aquifers. If a site is identified as being within an important natural resource area, additional testing may be needed to assess the threat of possible increased nitrate and phosphorous levels on groundwater quality
2. Conduct perc in the most limiting layer.

Ice-Contact Outwash

Characteristics:
1. VARIABLE - conditions change over short distances, very difficult to predict
2. Collapsed or slumped bedding
3. Well sorted to poorly sorted debris
4. Typically loose, sandy material but may include pockets or lenses of silty material
5. Dirty feel, often contains significant amounts of silt and clay
6. May include areas of stone and boulders



Associated Landforms:
1. Kames
2. Kettles
3. Eskers
4. Kame deltas
5. Kame terraces

Focus of On-Site Investigations:
1. Determine variability and extent of soil conditions
2. Document any restrictive layers

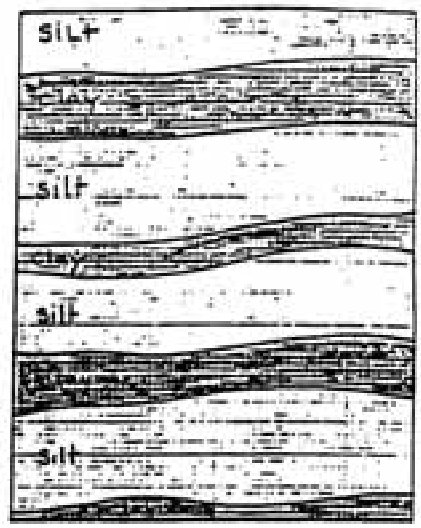
LAKEBED SEDIMENTS (LACUSTRINE)

Definition: Well sorted, fine textured sediments deposited originally at the bottom of glacial lakes, which has since drained.

Characteristics:
1. Well sorted, fine textured sediments
2. Generally high content of silt and/or clay
3. Rock fragments of gravel size and larger are typically absent

Associated Landforms:
1. Typically an undulating to rolling terrain and may have steep graded escarpments adjacent to water courses.

Focus of On-Site Investigation:
1. Typically slow to very slow perc rates
2. Check for vertical cracks in soils that may give erroneous perc rates
3. Very susceptible to smearing during wet periods
4. Poor internal drainage often causes these areas to be wet and have high seasonal water tables
5. Variable in some areas, particularly in old shoreline areas
6. Typically have thin layers of alternating silt and clay (varved) with the substratum



MARINE SILTS AND CLAYS

Definition: Areas of silts and clays deposited within a marine environment and have since been uplifted above present sea levels.

Characteristics:
1. Limited extent, only occurring in the Boston area and north, and only in those towns close to the coastline
2. VARIABLE - typically well sorted soils high in silts and clays
3. Locally referred to as blue clay

Associated Landforms:
1. Typically an undulating to rolling terrain, locally associated with land areas below certain elevations

Focus of On-Site Investigation:
1. Typically have slow to very slow perc rates
2. Very susceptible to smearing during wet periods
3. Poor internal drainage causes these areas to be wet and have high seasonal water tables
4. Variable within some areas

ORGANIC DEPOSITS

Definition: Bog, swamp and marsh deposits comprised mostly of partially and well decomposed organic material.

Characteristics:
1. Weak strength, spongy sensation when walked across
2. Very dark color
3. Little to no mineral material, smooth creamy feel no grittiness
4. Formed in areas with a seasonal high water table at or near the surface

5T-17

Associated Landforms:
1. Often within depressions and low lying areas adjacent to streams and lakes

Focus of On-Site Investigations:
1. These are wetland soil areas and should be avoided
2. Generally have a seasonal high water table at or near the surface for most of the year

COASTAL DUNE DEPOSITS

Definition: A natural hill, mound or ridge of sediment landward of a coastal beach deposited by wind action or storm overwash.

Characteristics:
1. Fine to coarse sands
2. Well sorted, often finely stratified
3. Little if no silt and clay, typically no gravel size or coarser rock fragments

Associated Landforms:
1. Ridges that often parallel the shoreline landward of the beach
2. Hills or mounds
3. Often have unvegetated areas of loose sand

Focus of On-Site Investigation:
1. Ever-changing landscape, susceptible to coastal erosion by wave action and strong winds
2. A protected resource area, CAUTION - check reference materials to determine extent of area

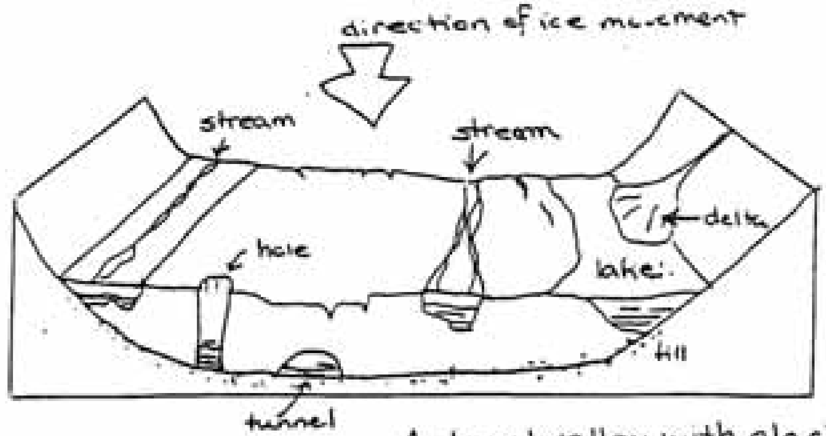
FLOODPLAIN (ALLUVIAL) DEPOSITS

Definition: Material transported and deposited by present day streams and rivers.

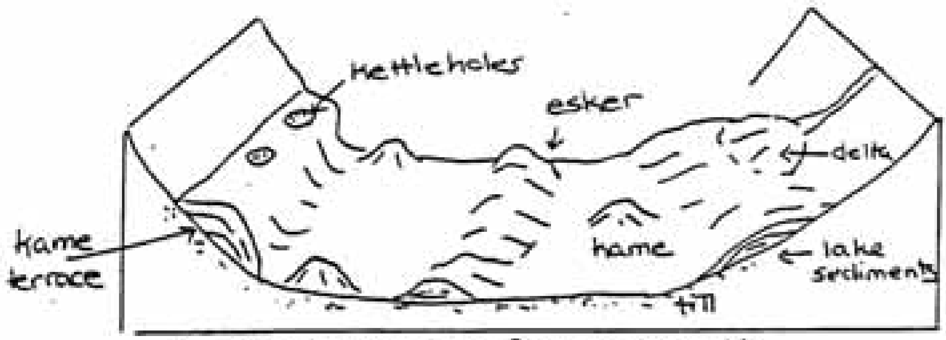
Characteristics:
1. Susceptible to seasonal flooding
2. Nearly level areas adjacent to large streams and rivers
3. Well sorted, often stratified
4. Fine textured, but may vary depending upon the velocity of the water
5. May have dark buried layers within the substratum that were at one time surface layers

Associated Landforms:
1. Floodplain
2. Stream terrace
3. Oxbow
4. Meander scar

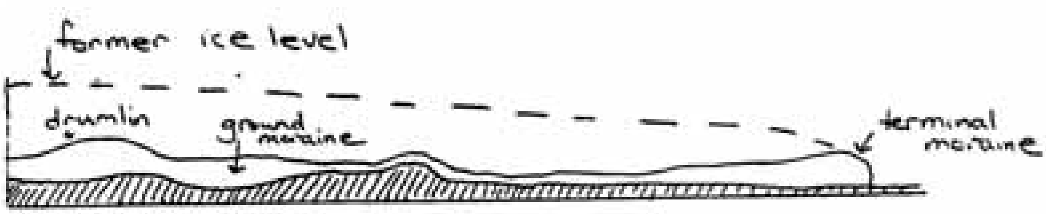
ST 20



A glacial valley with glacier



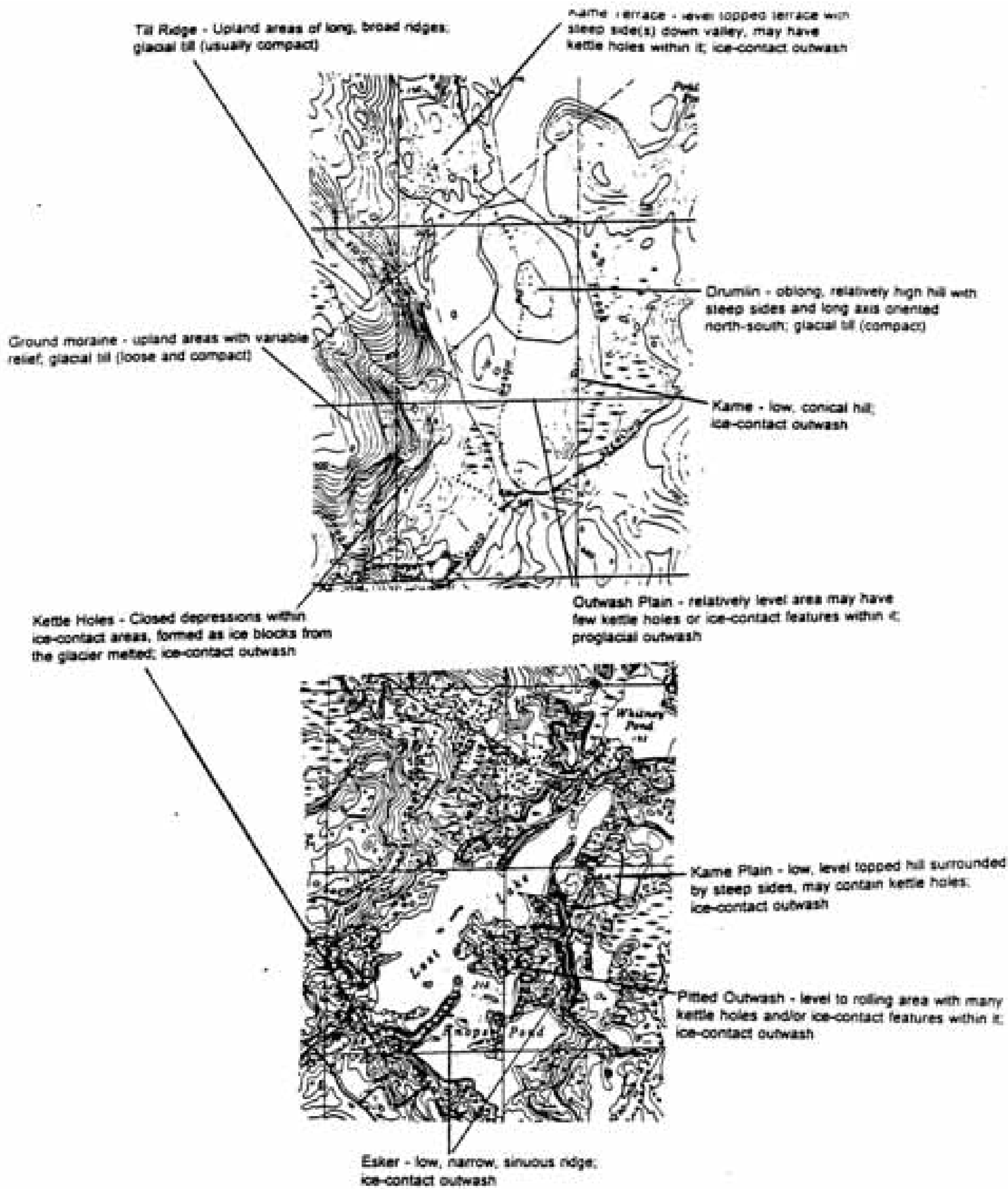
A glacial valley after ice melt



till deposits (side view)

Some
Glacial Deposits

GT21



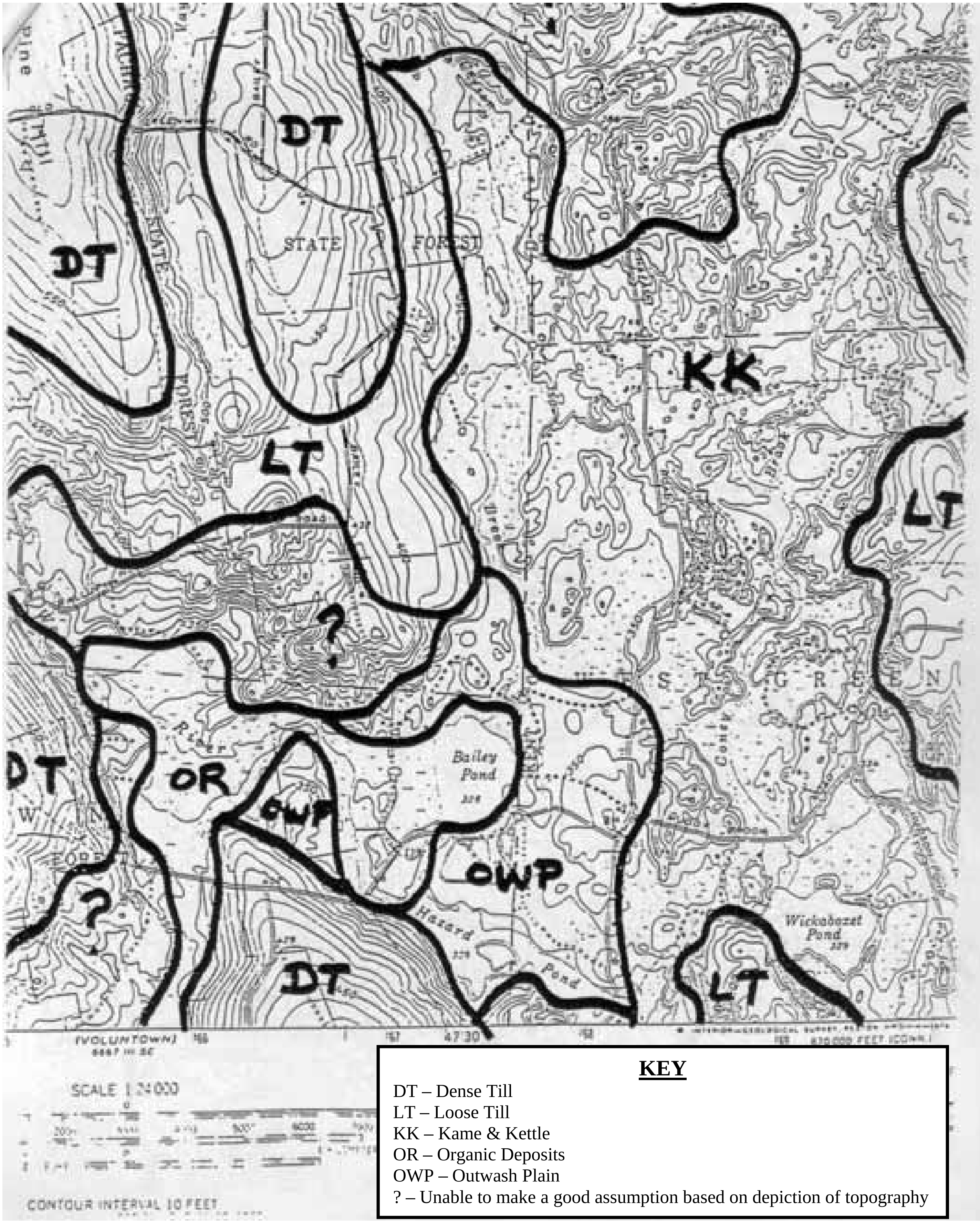
Till Ridge - Upland areas of long, broad ridges; glacial till (usually compact)
Kame Terrace - level topped terrace with steep side(s) down valley, may have kettle holes within it; ice-contact outwash
Drumlin - oblong, relatively high hill with steep sides and long axis oriented north-south; glacial till (compact)
Ground moraine - upland areas with variable relief; glacial till (loose and compact)
Kame - low, conical hill; ice-contact outwash
Kettle Holes - Closed depressions within ice-contact areas, formed as ice blocks from the glacier melted; ice-contact outwash
Outwash Plain - relatively level area may have few kettle holes or ice-contact features within it; proglacial outwash
Whitney Pond
Kame Plain - low, level topped hill surrounded by steep sides, may contain kettle holes; ice-contact outwash
Pitted Outwash - level to rolling area with many kettle holes and/or ice-contact features within it; ice-contact outwash
Esker - low, narrow, sinuous ridge; ice-contact outwash

ST22

Landforms and Soil Parent Materials

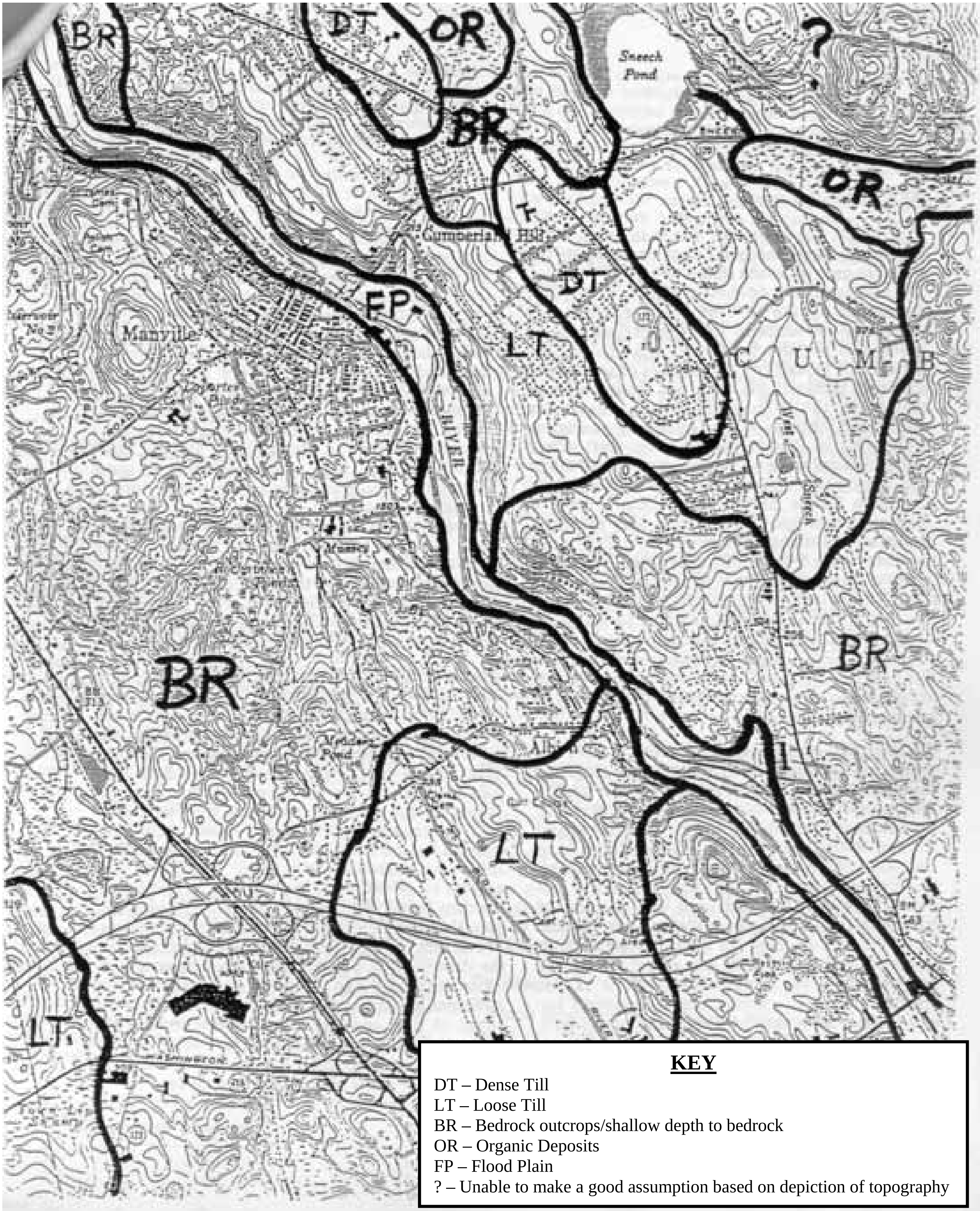
Parent Material	Landforms
Glacial Till Dense Till (DT) Basal Till Lodgement Till Compact Till	Drumlins Till Ridges Ground Moraine
Loose Till (LT) Ablation Till	Moraines
Outwash Proglacial outwash Ice-Contact Outwash	Outwash Plains Kames, Kettles, Eskers (KK)
Alluvial	Floodplain (FP), Stream Terrace
Eolian	Variable; outwash plains & till ridges
Organic Deposits (OR)	Depressions, low areas near streams and ponds
Coastal Dune	Coastal sites; shoreline beaches
Lacustrine	Glacial lakebed sediments
Shallow to Bedrock (BR)	Variable; often irregular

The following two pages provide some examples of various parent materials/geologic setting identified on topographic maps.



KEY

DT – Dense Till
LT – Loose Till
KK – Kame & Kettle
OR – Organic Deposits
OWP – Outwash Plain
? – Unable to make a good assumption based on depiction of topography


BR
DT
OR
?
Sneech Pond
BR
OR
Cumberland Hill
DT
FP
Manville
LT
C U M B
BR
BR
LT
LT
KEY
DT – Dense Till
LT – Loose Till
BR – Bedrock outcrops/shallow depth to bedrock
OR – Organic Deposits
FP – Flood Plain
? – Unable to make a good assumption based on depiction of topography

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http://nesoil.com/properties/index.htm

Soil Morphology as An Indicator of Seasonal High Water Tables

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Introduction:

The study of soils has a long tradition in the field of agriculture, but only during the last 2 decades has it become familiar to people concerned with site-suitability assessment for onsite sewage disposal. For instance a number of states, including Maine and New Hampshire, have adopted onsite sewage regulations partly or entirely based on soils information.

Highest groundwater levels and water table fluctuations are routinely estimated by soil scientists from a soil's morphology, mainly the soil color. Gray colors are associated with saturated and chemically reducing soil environments, while yellowish-brown colors are related to generally aerobic and chemically oxidizing conditions. Soils without any excess water during the year usually are aerated and yellowish-brown-colored. Soils with high water tables during some part of the growing season, generally the early spring when snow melts, exhibit gray coloration at the depth of the high water mark and below. The grayer the soil, the more distinct the wet period is. Many soils in New England exhibit both gray and yellowish-brown colors, reflecting the presence of an elevated water table in spring and a drier, more aerated condition during late spring and summer when the water table subsides.

Soil classification provides a powerful tool for assessing the soil-water state throughout the year, particularly the Estimated Average Seasonal High Water Table (EASHWT) level. This paper describes the environmental conditions affecting soil color formation, the role of saturated soil conditions in the creation of gray colors, the application of the Munsell system for soil colors, and the limitations of soil morphological criteria in determining the EASHWT.

Soil Color Formation

Soil colors are commonly associated with the presence or absence of iron. Weathering of soil minerals is a slow process but with time causes the release of mineral constituents to the environment. Soluble weathering-products are removed from the soil profile, while more stable compounds will precipitate. Iron (Fe), released from a mineral, frequently coats soil particles with thin oxide-coatings. Well-aerated soils typically are yellowish-brown-colored from these iron-oxide (Fe_xO_z) coatings. Depending on the intensity of the weathering cycles, the iron-oxides may display different colors. In New England, the dominant soil color is brown to yellowish-brown, caused by the mineral goethite (FeO.OH). Very intense weathering under well-aerated conditions causes formation of the red-colored mineral hematite (Fe_20_3), while the yellowish-colored mineral limonite ($FeO.OH.nH_20$) forms in more humid environments.

Soil is not a sterile medium but contains large numbers of microorganisms, which, under conditions favorable for their particular species, flourish and multiply greatly. Most of these organisms generate energy from the oxidation of soil organic-matter, which enables them to perform basic life functions. When the soil becomes saturated from flooding events or high groundwater levels, the oxygen in the soil system exhausts within a few days; anaerobic conditions prevail. The longer the saturation is, the greater the oxygen deficiency. Organisms that depend on oxygen for sustenance perish or become dormant. Under anaerobic conditions certain microorganisms can derive energy from the chemical reduction of compounds like oxidized iron (Fe^{3+}, called ferric iron) to reduced iron(Fe^{2+}, called ferrous iron). The energy thus generated is used to create life-sustaining chemical compounds for the bacteria from

This photo shows redox concentrations (bright yellowish-brown colors 10YR5/6 munsell color), redox depletions (gray colors - 2.5Y 6/1 colors) with a pale yellowish-brown matrix color (2.5Y 5/3 munsel color).

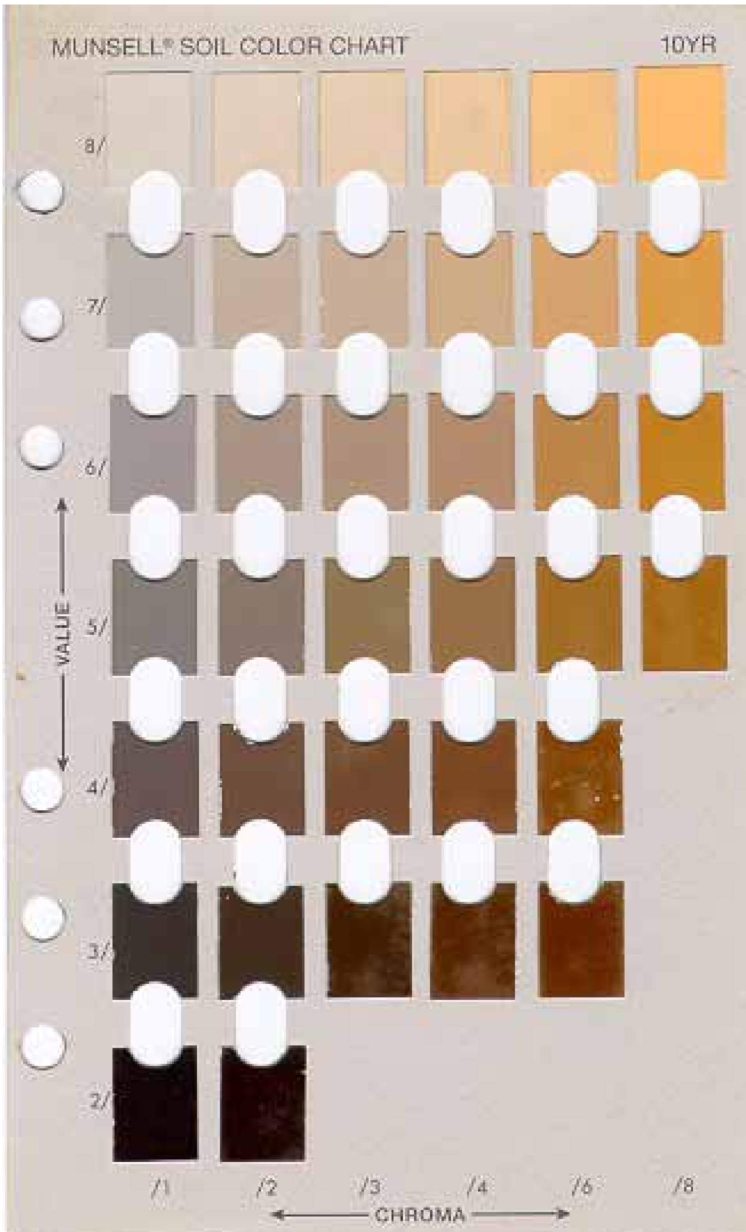
This photo shows a redox depletion (5BG 6/0 munsell color) along a dead root channel (visible in the center) with redox concentrations (10YR 5/6) around the depleteion.

soil organic-matter. Basic requirements for this reduction process are absence of oxygen, as induced by saturated soil conditions, temperatures above biological zero (41 degrees F), and presence of organic matter.
Prolonged soil-saturation results in anaerobiosis leading to the formation of mobile ferrous iron. The migrating groundwater redistributes the iron throughout the soil profile. Subsequent drainage restores aerobic conditions, but some iron coatings on the minerals may have been entirely removed, leaving the grayish surface of the mineral grains exposed. During drainage, some areas around pores, cracks, and root channels become dry and aerated more quickly than the rest of the soil. Ferric iron precipitates in these places, forming reddish-brown spots. During periods of alternating wetting and drying cycles, such as seasonal high groundwater, ferrous iron does not transfer out of the soil profile entirely but moves over short distances only and precipitates during the drying phase. Such conditions are characterized by blotches of gray and reddish-brown soil colors occurring at the same depth. The longer the saturation period, the more pronounced the reduction process, and the grayer the soil becomes. This pattern of spots or blotches of different color or shades of color interspersed with the dominant color is called soil mottling.

During the last 100 years, soil scientists used soil colors to predict the drainage status of a soil. Occurrence of gray colors at a particular depth marks the presence of elevated groundwater levels at that depth during part of the year. The grayish colors do not form rapidly but result from many cycles of soil saturation. Those colors are not easily obliterated; they serve as an almost permanent marker of the mean groundwater elevation at a site. Gray colors by themselves do not, however, indicate the duration of the anaerobic event, only that a water table exists there part of the year.

Munsell Color System

Soil colors are expressed in terms of hue, value, and chroma, in accordance with the standardized Munsell color system (Soil Survey Staff, 1951). Hue refers to the wavelength, value expresses the degree of lightness or darkness, whereas chroma notes the purity or strength of a particular color (Munsell, 1974). This system is used to describe the matrix or dominant soil color and the blotches of less-prevalent colors commonly called mottles.



10YR Munsell Page

Determining the Estimated Average Seasonal High Water Table

The presence of low chroma colors covering over 5% of the surface area exposed in a soil pit marks the level of the mean seasonal groundwater elevation in most New England soils-the Estimated Average Seasonal High Water Table (EASHWT). Low chroma colors result from reduction / oxidation cycles occurring over many years (generally in terms of centuries), which makes this estimation method a reliable and conservative indicator of maximum seasonal groundwater elevation. Occasionally, the groundwater may be found at shallower soil depths, but there is no scientifically sound method to assess accurately this highest-ever level. If that interval is short, aerobic soil conditions persist; consequently, no low chroma colors are formed.

Soil mottling within coarse textured sandy soils is typically less distinct and not as gray in color as those associated with finer textured soils. Interpreting the soil morphology within these areas is often more difficult. A soil feature unique to some coarse textured soils is a dark reddish or yellow layer often referred to as a rust line. This feature can form within the soil through two contrasting processes which may or may not be the result of a high water table. Those not associated with a water table may develop when percolating water is momentarily interrupted as it passes through different soil strata. This brief pause may cause dissolved iron within the water to precipitate out and over many years develop a bright red or yellow streak. This soil feature is common within some stratified sand and gravel deposits, and can often be observed on the sides of gravel pits high above any water table. This streaked or blotchy pattern of bright colors formed under aerobic soil conditions also is referred to as mottling.

Only in a few unique situations does a rust line result from a fluctuating water table. Rust lines associated with a water table are the result of the fluctuating water table and dissolved iron in the ground water. As the water level fluctuates, dissolved iron precipitates, forming a coating on the surface of soil particles and with time develops a bright red and yellow line in the soil. For a rust line to be interpreted as an indicator of the EASHWT elevation it should meet some or all of the following criteria: the rust line should appear as a nearly continuous band on all sides of the deep observation hole; it should be on a nearly level plane within the hole; soil mottling should be observed below the rust line; and in some situations dark nodules or layers (iron pans) of hardened or cemented soil material are present within the rust line. In situations where gray color mottles occur above a rust line, the elevation of the gray mottles not that of the underlying rust line, should be interpreted as the height of the EASHWT.

Low chroma colors are not always present, even though the soil has distinct periods of saturation. For instance, reddish-colored soils in Worcester County and in the Connecticut River Valley have such high iron contents that low chroma mottles are masked. Also, in soils developed in stratified deposits consisting of alternating layers of fine-grained and coarse- grained materials, the more clayey layers may be quite gray-even though the soil is never totally saturated and the maximum water table may actually be much deeper than the low chroma colors indicate. In such situations, the presence of the yellowish-brown-colored sandy layers shows that the drainage of that soil is much better.

Some of the coarser textured soils in Cape Cod and southeastern Massachusetts, and loamy in the Berkshires at elevations above 330 m (1100 ft) have a gray-colored layer directly below the topsoil. Incomplete breakdown of soil organic matter in the topsoil results in the formation of low molecular-weight organic acids, which causes extensive leaching in underlying soil layers unrelated to anaerobic soil conditions. The iron is stripped from the sand gains by the process of chemical complexation resulting in gray colors. Soil scientists call this process podzolization, and the brownish-colored underlying soil layers constitute a better indicator of the actual hydrology than the grayish-colored, leached layer. Other situations, where wet soil conditions do not necessarily cause distinct low chroma colors, occur in soils with organic matter distributed throughout the soil profile, such as in frequently flooded fluvial soils.

Sometimes soils exhibit low chroma colors that do not result from seasonal anaerobic conditions. Soils high in dark-colored phyllitic minerals inherited low chroma colors from their geologic parent materials; over 10,000 years of soil formation have not released sufficient iron to give the soil a uniform brown appearance. Also, some well-drained soils developed in glacial till are distinctly yellowish-brown-colored in the subsoil but become grayer with increasing depth because of the greater degree of weathering in the upper part of the profile. This does not necessarily indicate the presence of a elevated groundwater level.

Soil morphology is not a reliable indicator in drained soils. Soil colors and patterns develop as a result of a fluctuating seasonal high water table and leave an almost-permanent marker within a soil. Even when these soils have been drained for many years, this morphology persists and the altered hydrology may be misinterpreted. Areas of fill also present a problem. The time needed to develop soil wetness morphology within fill material is variable. Depending upon the kind of fill soil texture, presence of organic matter, kind of vegetative cover and chemistry of the ground water, the time needed to develop soil colors in fill material may vary from a few years to several decades or longer.
Soil science provides a powerful tool for interpreting the Estimated Average Seasonal High Water Table level throughout-the-year, even during dry seasons when water tables may not be present. In many situations, trained personnel without a formal soil science education can make reliable interpretations. However, in areas of unique and complex soil conditions or disturbed sites careful consideration of the soil's morphology, the kind of parent materials, the position of the soil in the landscape, and topography need to be assessed by a qualified soil scientist before a determination can be made.

Natural Soil Drainage Classes:

Soils are divided into drainage classes depending on the frequency and duration of periods of saturation or partial saturation during soil formation.

Excessively and somewhat excessively drained soils typically have sandy and gravelly textures within the subsoil and substratum. They have bright colors (strong brown to yellowish brown) in the subsoil that fade gradually with depth. Seldom are there mottles within the upper 5 feet of soil material and water tables are generally below 6 feet.
Well-drained soils typically have bright colors in the subsoil that fade gradually with depth. These soils are free of mottling to depths greater than 40 inches. Water tables are generally greater than 6 feet.
Moderately well drained soils generally have bright colors in the upper portion of the subsoil and are mottled between 15 and 40 inches beneath the soil surface. These soils are wet for a short but significant part of the year. Moderately well drained soils commonly have a restrictive layer, seepage water, or a seasonal high ground water table at a depth of 24 to 40 inches.
Somewhat poorly drained soils generally have grayish (chroma 3 or 4) subsoils underlain within 24 inches by horizons with low chroma dominant colors. The upper subsoil may or may not have mottles. Seasonal water table is between 12 to 24 inches.
Poorly drained soils typically have a blackish surface layer that is underlain by a gray subsoil that is mottled. These soils have a water table at or near the surface for a significant portion of the year.
Very poorly drained soils typically have ponded water on the surface or a water table at or near (<6" below) the surface for most of the year. Very poorly drained soils can be divided into those that developed in mineral deposits and those that developed in organic material. Very poorly drained mineral soils have a dark (black) organic surface layer underlain by a gray (gleyed) subsoil and substratum. Very poorly drained organic soils developed in thick, dark (often black) deposits of partially or well-decomposed organic matter, and are black in the topsoil, subsoil, and substratum.

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Soil Survey Staff. 1951. Soil survey manual. U.S. Dept. Agric. Handbook No. 18, U.S. Government Printing Office, Washington, DC.

The preceding paper and incorporated graphics provided by nesoil.com Base URL: http://nesoil.com/index.html
Website maintained by Jim Turenne

Glossary of Soil Terms

The following glossary of soil terms is provided for your convenience. Online glossaries of soil terms are available through **http://nesoil.com/; the glossary's URL is** http://nesoil.com/gloss.htm and the Soil Science Society of America website: http://www.soils.org/sssagloss/

Glossary

ABC soil. A soil having an A, a B, and a C horizon.

Ablation till. Loose, permeable till deposited during the final downwasting of glacial ice. Lenses of crudely sorted sand and gravel are common.

AC soil. A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep rocky slopes.

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali (sodic) soil. A soil having so high a degree of alkalinity (pH 8.5 or higher), or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

Very low	0 to 2.4
Low	2.4 to 3.2
Moderate	3.2 to 5.2
High	more than 5.2

Basal till. Compact glacial till deposited beneath the ice.

Base saturation. The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K), expressed as a percentage of the total cation-exchange capacity.

Bedding planes. Fine stratifications, less than 5 millimeters thick, in unconsolidated alluvial, eolian, lacustrine, or marine sediments.

Bedding system. A drainage system made by plowing, grading, or otherwise shaping the surface of a flat field. It consists of a series of low ridges separated by shallow, parallel dead furrows.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bench terrace. A raised, level or nearly level strip of earth constructed on or nearly on the contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Bisequum. Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.

Boston Basin. A low-lying physiographic area surrounding Boston. The area extends northward to the town of Lynn and southward to the town of Weymouth and includes the Boston Harbor Islands. It extends westward up the Charles River Valley to the town of Natick and southwestward up the Neposet River Valley to the town of Norwood. Most of the Boston Basin is less than 50 feet above sea level. The few hills that protrude above the plain are 50 to 160 feet above Mean Sea Level (MSL).

Bottom land. The normal flood plain of a stream, subject to flooding.

Boulders. Rock fragments larger than 2 feet (60 centimeters) in diameter.

Broad-base terrace. A ridge-type terrace built to control erosion by diverting runoff along the contour at a nonscouring velocity. The terrace is 10 to 20 inches high and 15 to 30 feet wide and has gently sloping sides, a rounded crown, and a dish-shaped channel along the upper side. It may be nearly level or have a grade toward one or both ends.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena. A sequence, or "chain," of soils on a landscape that formed in similar kinds of parent material but have different characteristics as a result of differences in relief and drainage.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Catsteps. Very small, irregular terraces on steep hillsides, especially in pasture, formed by the trampling of cattle or the slippage of saturated soil.

Cement rock. Shaly limestone used in the manufacture of cement.

Channery soil. A soil that is, by volume, more than 15 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches along the longest axis. A single piece is called a channer.

Chiseling. Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard compacted layers to a depth below normal plow depth.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Claypan. A slowly permeable soil horizon that contains much more clay than the horizons above it. A claypan is commonly hard when dry and plastic or stiff when wet.

Coarse fragments. If round, mineral or rock particles 2 millimeters to 25 centimeters (10 inches) in diameter; if flat, mineral or rock particles (flagstone) 15 to 38 centimeters (6 to 15 inches) long.

Coarse textured soil. Sand or loamy sand.

Cobblestone (or cobble). A rounded or partly rounded fragment of rock 3 to 10 inches (7.5 to 25 centimeters) in diameter.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex slope. Irregular or variable slope. Planning or constructing terraces, diversions, and other water-control measures on a complex slope is difficult.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

Compressible (in tables). Excessive decrease in volume of soft soil under load.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Conservation tillage. A tillage and planting system in which crop residue covers at least 30 percent of the soil surface after planting. Where soil erosion by wind is the main concern, the system leaves the equivalent of at least 1,000 pounds per acre of flat small-grain residue on the surface during the critical erosion period.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Contour stripcropping. Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Coprogenous earth (sedimentary peat). Fecal material deposited in water by aquatic organisms.

Corrosive. High risk of corrosion to uncoated steel or deterioration of concrete.

Cover crop. A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Deferred grazing. Postponing grazing or resting grazing land for a prescribed period.

Dense layer (in tables). A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

Depth to rock (in tables). Bedrock is too near the surface for the specified use.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically they are wet long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients.

Drainage, surface. Runoff, or surface flow of water, from an area.

Drumlin. A low, smooth, elongated oval hill, mound, or ridge of compact glacial till. The longer axis is parallel to the path of the glacier and commonly has a blunt nose pointing in the direction from which the ice approached.

Dry spot. This symbol is used on the soil maps to indicate an area 1 to 3 acres in size that is at least two drainage classes drier than the surrounding soil.

Eluviation. The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes the surface.

Erosion pavement. A layer of gravel or stones that remains on the surface after fine particles are removed by sheet or rill erosion.

Esker (geology). A narrow, winding ridge of stratified gravelly and sandy drift deposited by a stream flowing in a tunnel beneath a glacier.

Excess fines (in tables). Excess silt and clay in the soil. The soil is not a source of gravel or sand for construction purposes.

Excess lime (in tables). Excess carbonates in the soil that restrict the growth of some plants.

Excess salts (in tables). Excess water-soluble salts in the soil that restrict the growth of most plants.

Excess sulfur (in tables). Excessive amount of sulfur in the soil. The sulfur causes extreme acidity if the soil is drained, and the growth of most plants is restricted.

Fallow. Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grains are grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fast intake (in tables). The rapid movement of water into the soil.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat). The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

Fine textured soil. Sandy clay, silty clay, and clay.

First bottom. The normal flood plain of a stream, subject to frequent or occasional flooding.

Flagstone. A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist, 6 to 15 inches (15 to 38 centimeters) long.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Foot slope. The inclined surface at the base of a hill.

Forb. Any herbaceous plant not a grass or a sedge.

Fragile (in tables). A soil that is easily damaged by use or disturbance.

Fragipan. A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist, it tends to rupture suddenly under pressure rather than to deform slowly.

Frost action (in tables). Freezing and thawing of soil moisture. Frost action can damage roads, buildings and other structures, and plant roots.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Glacial drift (geology). Pulverized and other rock material transported by glacial ice and then deposited. Also, the sorted and unsorted material deposited by streams flowing from glaciers.

Glacial outwash (geology). Gravel, sand, and silt, commonly stratified, deposited by glacial meltwater.

Glacial till (geology). Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Glaciofluvial deposits (geology). Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur as kames, eskers, deltas, and outwash plains.

Glaciolacustrine deposits. Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial meltwater. Many deposits are interbedded or laminated.

Gleyed soil. Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors and mottles.

Graded stripcropping. Growing crops in strips that grade toward a protected waterway.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that is 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 3 inches (7.6 centimeters) in diameter.

Green manure crop (agronomy). A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water (geology). Water filling all the unblocked pores of underlying material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hardpan. A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

Hemic soil material (mucky peat). Organic soil material intermediate in degree of decomposition between the less decomposed fibric and the more decomposed sapric material.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. The major horizons are as follows:

O horizon.—An organic layer of fresh and decaying plant residue.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, any plowed or disturbed surface layer.

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon.—The mineral horizon below an O, A, or E horizon. The B horizon is in part a layer of transition from the overlying horizon to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) granular, prismatic, or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying horizon. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon.—Soft, consolidated bedrock beneath the soil.

R layer.—Hard, consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon but can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil. A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity. The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate. The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake in inches per hour is expressed as follows:

Less than 0.2	very low
0.2 to 0.4	low
0.4 to 0.75	moderately low
0.75 to 1.25	moderate
1.25 to 1.75	moderately high
1.75 to 2.5	high
More than 2.5	very high

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are—

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlle by small earth ridges called border dikes, or borders.

Basin.—Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Controlled flooding.—Water is released at interva from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle).—Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters porous tubing, or perforated pipe.

Furrow.—Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler.—Water is sprayed over the soil surfac through pipes or nozzles from a pressure system

Subirrigation.—Water is applied in open ditches c tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Water, released at high points, is allowed to flow onto an area without controlled distribution.

Kame (geology). An irregular, short ridge or hill of stratified glacial drift.

Karst (topography). The relief of an area underlain by limestone that dissolves in differing degrees, thus forming numerous depressions or small basins.

Lacustrine deposit (geology). Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Landslide. The rapid downhill movement of a mass of soil and loose rock, generally when wet or saturated. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Large stones (in tables). Rock fragments 3 inches (7.t centimeters) or more across. Large stones adversely affect the specified use of the soil.

Leaching. The removal of soluble material from soil or other material by percolating water.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Low strength. The soil is not strong enough to support loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Metamorphic rock. Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement. Nearly all such rocks are crystalline.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

Moderately coarse textured soil. Coarse sandy loam, sandy loam, and fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, and silty clay loam.

Moraine (geology). An accumulation of earth, stones, and other debris deposited by a glacier. Some types are terminal, lateral, medial, and ground.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent.* The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium,* from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse,* more than 15 millimeters (about 0.6 inch).

Muck. Dark colored, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Munsell notation. A designation of color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Narrow-base terrace. A terrace no more than 4 to 8 feet wide at the base. A narrow-base terrace is similar to a broad-base terrace, except for the width of the ridge and channel.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

Outwash plain. A landform of mainly sandy or coarse textured material of glaciofluvial origin. An outwash plain is commonly smooth; where pitted, it is generally low in relief.

Pan. A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan.*

Parent material. The unconsolidated organic and mineral material in which soil forms.

Peat. Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material).

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil, adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	less than 0.06 inch
Slow	0.06 to 0.2 inch
Moderately slow	0.2 to 0.6 inch
Moderate	0.6 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management. For material underlying the soil and grading to hard bedrock below.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Sequum. A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the substratum. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silica. A combination of silicon and oxygen. The mineral form is called quartz.

Silica-sesquioxide ratio. The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone. Sedimentary rock made up of dominantly silt-sized particles.

Similar soils. Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Sinkhole. A depression in the landscape where limestone has been dissolved.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75 feet.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on the steeper slopes; on faces of blocks, prisms, and columns; and in swelling clayey soils, where there is marked change in moisture content.

Slick spot. A small area of soil having a puddled, crusted, or smooth surface and an excess of exchangeable sodium. The soil is generally silty or clayey, is slippery when wet, and is low in productivity.

Slippage (in tables). Soil mass susceptible to movement downslope when loaded, excavated, or wet.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope (in tables). Slope is great enough that special practices are required to ensure satisfactory performance of the soil for a specific use.

Sloughed till. Water-saturated till that has flowed slowly downhill from its original place of deposit by glacial ice. It may rest on other till, on glacial outwash, or on a glaciolacustrine deposit.

Slow intake (in tables). The slow movement of water into the soil.

Slow refill (in tables). The slow filling of ponds, resulting from restricted permeability in the soil.

Small stones (in tables). Rock fragments less than 3 inches (7.6 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates, in millimeters, recognized in the United States are as follows:

Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5

Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and plant and animal activities are largely confined to the solum.

Stone line. A concentration of coarse fragments in a soil. Generally, it is indicative of an old weathered surface. In a cross section, the line may be one fragment or more thick. It generally overlies material that weathered in place and is overlain by recent sediment of variable thickness.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter.

Stony. Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stripcropping. Growing crops in a systematic arrangement of strips or bands which provide vegetative barriers to wind and water erosion.

Structure, soil. The arrangement of primary soil particles into compound particles or **aggregates.** The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Stubble mulch. Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling. Breaking up a compact subsoil by pulling a special chisel through the soil.

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Summer fallow. The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from about 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Surface soil. The A, E, AB, and EB horizons. It includes all subdivisions of these horizons.

Terminal moraine. A belt of thick glacial drift that generally marks the termination of important glacial advances.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer (in tables). Otherwise suitable soil material too thin for the specified use.

Till plain. An extensive flat to undulating area underlain by glacial till.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Toxicity (in tables). Excessive amount of toxic substances, such as sodium or sulfur, that severely hinder establishment of vegetation or severely restrict plant growth.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, are in soils in extremely small amounts. They are essential to plant growth.

Unstable fill (in tables). Risk of caving or sloughing on banks of fill material.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Valley fill. In glaciated regions, material deposited in stream valleys by glacial meltwater. In nonglaciated regions, alluvium deposited by heavily loaded streams.

Variegation. Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Varve. A sedimentary layer of a lamina or sequence of laminae deposited in a body of still water within a year. Specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Well graded. Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wilting point (or permanent wilting point). The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

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   The new EPA Manual (Reference Number 7) complements the "Design Manual for Onsite Wastewater Treatment and Disposal Systems" (EPA-625/180-012) that was originally published in 1980. The Manual is available for download via a link on the DEM website:

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